

Figure 6 - Plan of Vertical Sections

Argent (Property Development)
Services LLP

**Railway Children Theatre, King's
Cross Central Zone A**

Earthworks Specification

REP/2014/003

Draft 1 | 26 September 2014

Draft

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 233634-01

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Document Verification

ARUP

Job title		Railway Children Theatre, King's Cross Central Zone A		Job number		233634-01	
Document title		Earthworks Specification		File reference		60_1	
Document ref		REP/2014/003					
Revision	Date	Filename	Earthworks Specification – Railway Children – DRAFT1.docx				
Draft 1	26 Sep 2014	Description	First draft				
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		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					
		Signature					
		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					
		Signature					
		Issue Document Verification with Document					
		<input checked="" type="checkbox"/>					

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Abbreviations and Definitions

Arup	Ove Arup and Partners Ltd
AR(N)	Access Ramp (North)
AR(S)	Access Ramp (South)
BNL	BAM Nuttall Limited
BTEX	benzene, toluene, ethylbenzene and xylenes
CDMC	Construction, Design and Management co-ordinator (BCAL Consulting)
CIEH	Chartered Institute of Environmental Health
CIRIA	Construction Industry Research and Information Association
CL:AIRE	Contaminated Land Applications in Real Environments
CLEA	Contaminated Land Exposure Assessment
CM	conceptual model
CTRL	Channel Tunnel Rail Link
CP	cable percussion
Defra	Department for Environment, Food and Rural Affairs
DICoP	CL:AIRE "The Definition of Waste: Development Industry Code of Practice"
DWS	drinking water standards
EA	Environment Agency
ENVIRON	ENVIRON UK Limited
ER	employer's requirements
ERP	earthworks and remediation plan
EQS	environmental quality standards
ES	environmental statement
FES	Foundation Exploration Services
Formation Level	The general level of the ground (London Clay) in Sub-Areas 1, 2, 3 and 4 at the end of the Early Works contract
GAC	generic assessment criteria
GTS	Ground Technology Services
ISR	Interim Service Road
KXC	King's Cross Central
KCCLP	King's Cross Central Limited Partnership (the Landlord)
LBC	London Borough of Camden
LEC	landlord's environmental consultant (Arup)
LQM	Land Quality Management
m AOD	metres above Ordnance Datum
mbgl	metres below ground level
MMP	Materials Management Plan (prepared in accordance with DICoP)
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyls

PID	photo-ionisation detector
PPL	plausible pollutant linkage
RIVP	remediation implementation and verification plan
RWC	remediation works contractor (BNL)
SGV	soil guideline value
SSY	Shared Service Yard
SPR	source-pathway-receptor
TEC	The Tenant's environmental consultant (Environ)
VOC	volatile organic compound
WQS	water quality standards

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1 Introduction

1.1 Scope

Ove Arup and Partners International Limited (Arup) has been commissioned by Argent (Property Development) Services LLP to provide geotechnical and environmental design services for the creation of a level platform to allow the installation of a temporary structure which will house the Railway Children Theatre.

The level platform is to be created on the site of a future Google building which is currently under design. Arup has previously been involved in the plot through the provision of environmental services for the remediation of the soils contaminated by a former gas works at this location.

This document contains the earthworks specification as well as specific details of the environmental requirements for the imported fill.

1.2 Exclusions

This report does not cover the requirement for surface water or foul drainage across the site. It is envisaged that filter drains will be installed through the level platform around the perimeter of the temporary theatre to collect surface water and discharge into existing drainage installed as part of the remediation works.

Foul drainage design will be carried out once the positions of the temporary welfare facilities are confirmed.

1.3 Use of the Report

This report has been produced for the use of Argent in connection with the proposed temporary development of Zone A. It is not intended for and should not be used or relied upon by any third party, except as provided for in Arup's agreement with Argent.

2 The Site

2.1 Location

The proposed location of the temporary theatre is on the northern half of Zone A, as indicated on Figure 1. Additional information is also provided on Figure 2.

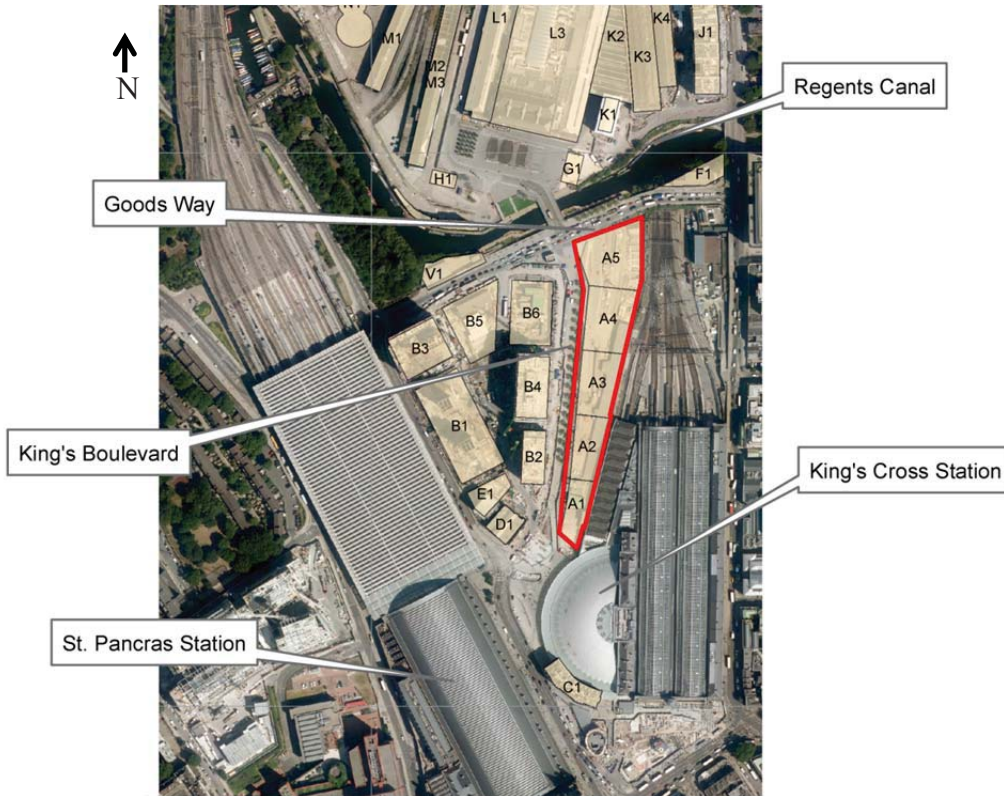


Figure 1 Site location within the King's Cross Development



Figure 2 'Sub Area' layout within the Zone A site.

Goods Way runs east-west on the northern side of Zone A and pedestrian access to the theatre would be down the Interim Service Road (ISR). On the eastern side of Zone A is the ramp road from Goods Way to the underground Network Rail Shared Service Yard (SSY), situated at the southern end of Zone A. The SSY and

the southern half of the access road (Access Ramp South (AR(S))) was constructed in 2008/9 and opened in 2010. This concrete box structure is supported on two lines of contiguous piles.

The Access Ramp (North) (AR(N)) is an elevated concrete box structure, also supported on two lines of contiguous piles, except for a piled raft at the northern entrance from Goods Way.

2.2 Surface Conditions

The existing topography on the site is complex and arises mainly from the construction of the Interim Service Road (ISR) in 2009/10 and from the “Early Works” site preparation, remediation and piling works undertaken in 2013. For the purposes of the remediation works Zone A was split into five ‘Sub-Areas’ which can be seen on Figure 2.



Figure 3 ‘Sub Area’ layout within the Zone A site.

Along the western side of the proposed footprint of the theatre is the ISR, which was the former vehicular access into the Access Ramp (South) (AR(S)) as well as the site access into Zone A during the Early Works remediation and construction of the AR(N) in 2013. The levels of the ISR range from ~24.2mAOD at the top where it meets Goods Way and ~16.2mAOD in south where it meets the former entrance to the AR(S) in the middle of the site. There is a gabion wall running along the western side of the ISR and has a maximum elevations of approximately 21.9mAOD.

Over the remainder of the footprint of the theatre, there is excavated ground to the north and south with a ridge of ground at a higher level across the centre running west-east from the bottom of the ISR to an entry into the northern end of the AR(S).

London Clay levels in Sub-Areas 2 and 3 (Figure 3) range between 13.5mAOD in the south and 14.5mAOD in the north. London Clay levels in Sub-Area 4 (Figure 4) beneath the Type 1 rock aggregate berm are approximately 16mAOD. Drawings showing the finished surface levels are presented in Appendix A on drawings BAP1130 ZA C7.02 SK130 and SK145.



Figure 4 Current view of Sub-Area 2 and 4 looking south.

As part of the Early Works, supporting structures and hydraulic cut offs were installed in Sub-Area 4 and Sub Area 3. The supporting berm in Sub-Area 4, comprising MOT Type 1 rock aggregate, has a top of berm level of 18.0mAOD and is shown in Figure 3.

Along the western edge of Sub-Area 3 a hydraulic barrier is formed of an in-ground clay barrier, with a raised clay bund on top. The clay barrier was then capped with MOT Type 1 rock aggregate with a 1:1.5 batter, and is subsequently capped with concrete. The site condition of Sub-Area 3 is shown in Figure 4.



Figure 5 Current view of Sub-Area 4 looking south

3 Proposed Works

The proposed works are to raise ground levels within the between the AR(N) / AR(S) on the east side of the site and the berm / ISR on the west side of the site. The finished elevation is to coincide with the level of the Type 1 berm that is present in Sub-Area 4, which is at 18mAOD. At typical cross-section through Sub Areas 2 and 4 is presented in Figure 6.

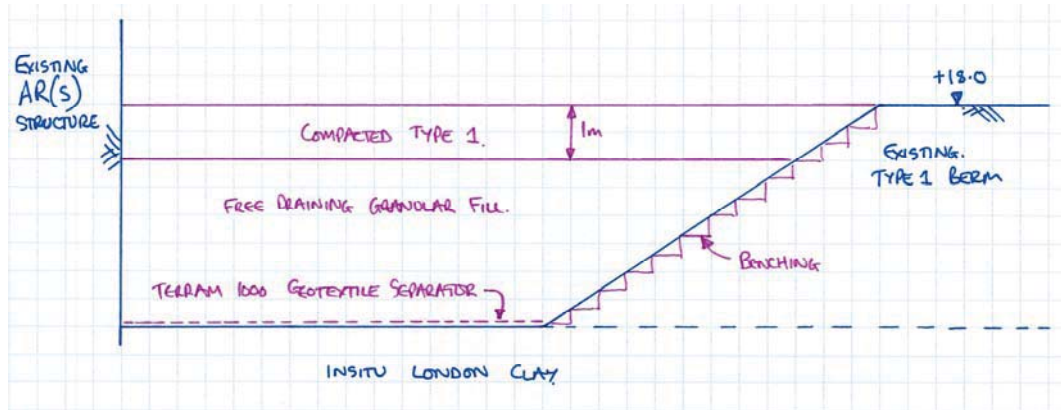


Figure 6 Typical filling profile in Sub Area 2 and 4

In order to carry out the filling works, the designers of the AR(N) / AR(S) have confirmed that the structure can adequately resist the increased lateral earth pressures as well as theatre surcharge loading.

Arup has carried out the design of a temporary retaining wall across the original entrance to the AR(S) from the ISR. At this location the level of the access is between 16.1 and 16.3mAOD, therefore requiring a retaining wall in the order of 2m high. The design of the retaining wall is contained in Appendix B.

The design of filter drains for surface water collection will be carried out once the footprint of the theatre has been confirmed. The same is applicable for the foul drainage.

3.1 Structural Fill Requirements

As part of the remediation already carried out on the site, Google has very specific requirements on the type of fill that can be used to raise levels. As such all fill is to comprise of quarried virgin rock aggregate from one of the two approved sources:

- Hanson Aggregates, Whatley Quarry, Somerset (Limestone).
- Lafarge, Mountsorrel Quarry, Leicestershire (Granite)

Two types of fill are required and include a Type 1 as specified in the Specification for Highway Works, Series 800 for the top 1m below the finished level of 18mAOD. The second material is to be placed below 17mAOD, and is a site specific free draining material known as '064B544/4/40' supplied by Hanson Aggregates. The grading for this material is provided in Table 1 and testing is to be carried out using dry grading to BS EN 933-1. A copy of the Hanson data sheet is contained in Appendix C.

Table 1 Grading of '064B544/4/40'

Sieve Size (mm)	Percentage Passing Limits (%)
80	100
63	98-100
40	90-100
20	25-60
4	0-15
2	0-5
0.063	0-4

Compaction, testing and environmental requirements for the proposed fills are provided in the specification (Section 4) and Appendix D, respectively.

3.2 Geometry of the Proposed Fill

The exact geometry of the proposed filling is currently being finalised by others. The proposed platform is to be level at 18mAOD. A fall of 1% is to be provided across the site, however the exact details of this are still to be confirmed.

In addition the limits of the fill in the north and south direction are also to be confirmed. The specification for the earthworks is unlikely to change as a result of confirmation of these details. At the limits of the 18mAOD platform the fill batter slopes should slope down at a gradient not exceeding 1v in 2h. All slopes are to be capped with 1m of Type 1 material to prevent degradation of the free draining '064B544/4/40' material.

3.3 Geotextiles

A geotextile separator is to be used on separate imported fill from the exposed London Clay as well as un-remediated Made Ground (e.g. around the ISR). The geotextile is to be a Terram 1000 or similar approved.

3.4 Geogrids

It is understood that the contractor has proposed the use of a geogrid in the starter layer of fill above the softened in-situ London Clay. The details of the geogrid are to be confirmed by the Contractor as they are not part of the Arup scope.

4 Earthworks Specification

The following contract-specific appendices and clauses have been prepared to supplement the requirements of the Highways Agency ‘Specification for Highway Works’ (SHW). These contract-specific appendices are to be read in conjunction with the SHW.

SHW Series	Appendix	Title
100	1/5	Testing to be carried out by the Contractor
600	6/1	Requirements for acceptability and testing etc. of earthworks 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 and preparation and surface treatment of formation

Appendix 1/5 – Testing to be carried out by the Contractor

Series 600					
SHW Clause	Acceptable material				
	Class	General Description	Test	Frequency	Notes
Contract Specific	‘064B544/4/40’	General free draining granular fill	Refer to Appendices 6/1 and 6/3.		
800	Type 1	Unbound material	Refer to Appendices 6/1 and 6/3.		

Appendix 6/1 – Requirements for Acceptability and Testing etc of Earthworks Materials

1. The Contractor is responsible for the classification and confirmation of acceptability of all earthwork materials.
2. Earthworks materials to be used in the Contract include:

Relevant SHW Series	Classification	Permitted Use
Contract Specific	‘064B544/4/40’	General granular free draining fill between existing levels and 17mAOD.
803	Type 1	Final 1m thickness of fill to bring levels to 18mAOD. Also used beneath temporary precast retaining wall units where shown on drawings.

3. Testing of earthworks materials shall be undertaken at three stages within the execution of the works:
 - a. To prove the overall suitability/acceptability of the intended source to meet Specification requirements (Appendix 6/1 Cl. 4-5 and Table 6/1 and 6/2);
 - b. To prove the relationship between the material and compaction, for the compaction trial (Appendix 6/3 Cl. 8);
 - c. To prove the ongoing quality of the material being imported and used to construct the permanent works (Appendix 6/3 Cl. 9-12 and Table 6/4).

Where variability in the test results of material composition/properties is noted, the Supervisor may nominate further testing as required.

4. Acceptability testing shall comprise a minimum of the following (Table 6/1) for each source and type of material to be used in the contract, and be provided to the Overseeing Organisation prior to the commencement of the works as a complete package of test results. The results shall be not more than 4 weeks old at the date of submission.

Table 6/1 - Material Acceptability Test Requirements Prior to Import

Property test	Rate of tests per source*	Defined in accordance with:
Determination of the particle density	1 per 500m ³ intended for import	BS 1377, Part 2, Cl 8
Determination of the particle size distribution		BS 1377, Part 2, Cl 9.2 or BS EN 933-1 for Dry grading
Moisture Content Determination		BS 1377, Part 2, Cl 3.2
Determination of the plasticity index (% of material passing the 425µm sieve, % of material retained to be reported).		BS 1377, Part 2, Cl 4.3, 5.3, 5.4
Determination of the total sulphate content and pH		BS 1377, Part 3, Cl 5.5 & 9
Determination of the dry density/moisture content relationship of soil (2.5kg rammer method).		BS 1377, Part 4, Cl 3.5
Determination of natural bulk and dry density.		BS 1377, Part 9
*Not less than 3 no. suites per source.		

5. For imported materials, the origin and source location shall be checked and certified in advance with chemical testing. This shall include confirmation of the origin and type of material and a minimum of five (5) samples tested before importation for the parameters set out in Appendix D of this Specification. The imported material is also to conform to information provided in Table 6/2. The Contractor shall confirm the material is acceptable in this manner and submit the information to the Overseeing Organisation one week before the material is imported to site.

Table 6/2 Acceptable Earthworks Materials - Classification and Compaction

Class	General material Description	Typical Use	Permitted constituents	Material Properties				Compaction Requirements	
				Property	Defined in accordance with:	Acceptable Limits Within:			
						Lower	Upper		
Free Draining Granular Fill	064B544/4/40	Free draining granular material	Fill for ground-level raises up to 17mAOD	Natural material only from sources provide in Section 3 of report	Grading	BS 1377: Part 2 or BS EN 933	Refer to Table 1 of Section 3.1 of this report	Refer to Table 1 of Section 3.1 of this report	SHW600 Table 6/4 Method 2 (subject to compaction trial)
					Clay Fraction	BS 1377: Part 2			
					Moisture content	BS 1377: Part 2	OMC-3%	OMC+3%	
					pH	BS 1377 : Part 3	6	8	
					water soluble (WS) sulfate content	TRL Report 447 Test No. 1	-	1500mg/l	
					oxidisable sulphides (OS) content	TRL Report 447 Tests Nos. 2 and 4	-	0.5%	

Table 6/2 continued Acceptable Earthworks Materials - Classification and Compaction

Class		General material Description	Typical Use	Permitted constituents	Material Properties				Compaction Requirements
					Property	Defined in accordance with:	Acceptable Limits Within:		
							Lower	Upper	
Unbound mixture	Type 1 (to SHW800)	Unbound mixture	Fill below new temporary retaining wall and above 17mAOD	Engineered granular fill	Grading + clay fraction		SHW800	SHW800	Compaction Trial: In accordance with 6/3 Cl 8. <i>(and followed by)</i> End Product: 98% of maximum dry density and of BS1377: Part 4 (2.5kg rammer method)
					Moisture Content ^[a]	BS 1377: Part 2	OMC-2%	OMC+2%	
					pH	BS 1377: Part 3	6	8	
					water soluble (WS) sulfate content	TRL Report 447 Test No. 1	-	1500mg/l	
					oxidisable sulphides (OS) content	TRL Report 447 Tests Nos. 2 and 4	-	0.5%	

Note:
^[a] – acceptable moisture content range shall be subject to interpretation of the moisture/compaction relationship for the proposed materials.

Appendix 6/3 – Requirements for excavation, deposition, compaction (other than dynamic compaction)

1. The contract drawings (provided by others) give related earthworks requirements including line and level.
2. The Contractor shall prepare method statements for all activities required by the Specification and this Appendix, and shall be submitted to the Project Manager not less than 7 days prior to undertaking the works;
3. The Contractor shall prepare an “Earthworks Management Plan” document describing their intentions for:
 - a) Importing and stockpiling of material prior to compaction
 - b) Protective measures for stockpiles during adverse weather
 - c) Methods to adjust the moisture content on site to meet compaction requirements
 - d) Methods for achieving uniformity of material such that tests are representative and construction materials are suitable (blending etc)
4. The Contractor shall prepare an “Inspection and Test Plan” document to describe the materials testing to be undertaken as a part of the Works to meet the requirements of the Specification and this Appendix. This shall include blank examples of record sheets and registers for the ongoing monitoring of material parameters as required by this Appendix. This shall be submitted to the Project Manager for approval prior to the commencement of each phase of work or activity requiring testing.
5. Blasting for excavation is not required and shall not be permitted.

6. Cutting Faces

- (i) Cutting is limited only to benching in material to the Type 1 berm present in ‘Sub-Area 3’. No cutting is permitted within the ISR and to the north of the ISR in ‘Sub-Area’ 4. The Contractor must comply with the requirements of the Health and Safety Executive when excavating trenches or openings, and such excavations must be safe and supported.
- (ii) Trench excavations into existing material are not permitted.
- (iii) Clearing of loose material by airline hose is not permitted.

7. Earthworks Construction

- (i) Only plant and working methods which are suited to the materials to be handled and traversed shall be employed in the construction of the permanent works.

- (ii) Temporary slope batters shall not be formed steeper than 1V:2H. If the Contractor proposes to use temporary slopes steeper than this, he shall submit details (including testing and calculations) to the Project Manager for agreement prior to the commencement of such works.
- (iii) Surcharging for consolidation purposes is not required.
- (iv) The formation shall be kept dry and free of standing water at all times with an adequate temporary drainage crossfall of at least 1%.
- (v) All fill materials shall be constructed with a crossfall of at least 1%, to avoid ponding of water during adverse weather and during stoppage of construction.
- (vi) Prior to the commencement of daily compaction operations, the area to be worked shall be subject to a walk-over inspection for any areas of ponding, softening, or deterioration of the formation.
- (vii) Where adverse weather softens or deteriorates the surface of compacted fill between lifts, or water ponds in undulations or depressions in the surface of the compacted fill, the surface shall be scraped of softened or poor material until material unaffected by adverse weather is exposed.
- (viii) Re-use of site won materials is not permitted.
- (ix) All formation subgrades shall be proof-rolled prior to fill placement.
- (x) A minimum undrained shear strength value of 25 kN/m² is required for all formations in cohesive soils or Made Ground. This shall be identified using a hand vane and proof-rolling.
- (xi) Soft spots or soft areas in formations shall be defined as areas where the soil does not meet the minimum shear strength requirements and should be identifiable by the fact that the soil does not support the roller weight during proof-rolling without excessive deformation. The extent of soft spots shall be determined by inspection during proof-rolling. The contractor may be permitted to use a geogrid above the existing formation level to enable compaction of the initial layers of fill material.

Soft spots each with an area in plan of 10 m x 10 m or less shall be excavated and replaced with compacted granular fill.

Records of the subgrade inspections carried out, and any remedial measures necessary including the location and depth of any soft spots or soft areas encountered, shall be submitted to the Project Manager.

- (xii) Any oversized material (ie. in excess of the upper grading limit) observed during placement of fill shall be removed prior to compaction.

8. Compaction Trial

- (i) A compaction trial of each proposed fill material shall be undertaken to confirm the ability of plant and methods to achieve compaction in accordance with this Specification;
- (ii) The Contractor shall submit to the Project Manager a proposal and method statement outlining how they intend to undertake the compaction trial and meet the requirements of the Specification;
- (iii) A trial shall be undertaken on each material type imported, at optimum moisture content with the intention of achieving the specification dry density;
- (iv) A minimum of 3 layers shall be undertaken for each combination of passes and layer thickness, with the lowest layer not subject to testing;
- (v) Each trial shall be of plan dimensions not less than 5m x 10m;
- (vi) Loose layer thickness shall be measured by optical levelling methods at a minimum of 5 points across each layer prior to compaction. The compacted thickness shall be measured post-compaction. These measurements shall be recorded for later reference.
- (vii) Compaction shall be undertaken to an appropriate 'Method' for Class '064B544/4/40', or commence as estimated by the Contractor for Type 1 materials;
- (viii) Bulk samples shall be collected and tested at the rate of 2 no. samples per 50m² for each layer of the compaction area. These shall be in addition to any tests for suitability testing.

Laboratory testing shall comprise of:

- a. Particle size distribution including by hydrometer methods;
- b. Moisture content;
- c. Atterberg limits;
- d. Dry density-moisture content relationship;
- e. And any other tests for calibration of nuclear density meter equipment.

In situ measurements shall be undertaken at the rate of 2 no. sets of tests per 50m² for each layer of compaction area using nuclear density meter or sand cone replacement testing of:

- a. In situ density;
- b. In situ moisture content.

Where nuclear density meter (NDM) testing is used, each test location shall comprise a pair of NDM tests, rotated by 180° between tests.

- f. The range of moisture content (ie. +/- of OMC) to which the material can be adequately compacted to meet %MDD shall be presented on compaction graphs;
- g. The compaction plant and compactive effort utilised in the trial shall be comparable to the plant for the permanent Works, and records shall be maintained of plant, passes, and layer thicknesses used;
- h. The trial may form a portion of the permanent Works, provided that validation testing determines that the trial meets the overall compaction requirements;
- i. Following the compaction trial, the Contractor shall submit a report to the Project Manager for his acceptance with the details of plant type, test locations and sketches, thickness measurements, test frequencies, test results and the proposed compaction technique (passes/thickness) to be used for the permanent works.

9. Compaction

- (i) Compaction shall be carried out in accordance with Clause 612 of SHW600;
- (ii) The materials shall be subject to either Method compaction or End-Product compaction requirements, as per Table 6/2 of Appendix 6/2. End-Product testing is to be carried out at the rates specified in Table 6/3 of this Appendix;
- (iii) The Contractor shall be responsible for ensuring the materials are at an appropriate moisture content to achieve the compaction requirements of the Specification Appendix.

Prior to compaction of earthworks materials, the specific batch/stockpile to be compacted shall be subject to daily moisture content testing to confirm the field moisture content is within limits acceptable for compaction. Where greater than 50m³ is to be imported and compacted on a daily basis, further tests shall be undertaken at 1 (one) no. per 50m³.

Quick techniques such as the use of microwave oven methods shall be permitted subject to a minimum of 20 no. tests being undertaken and correlated to tests undertaken to oven drying methods to BS1377-2:1990. The tests shall be regularly distributed throughout the source material for use in the earthwork construction. Where the variance is greater than +/- 2% microwave methods shall not be permitted.

Moisture content shall be re-confirmed following any periods of adverse weather.

All moisture content results shall be recorded in a register and shall be made available to the Supervisor on request. A report shall be submitted to the Project Manager on a weekly basis.

- (iv) Where earthworks materials require correction of the moisture content (ie. drying or wetting) prior to compaction, additional moisture content tests

shall be undertaken to confirm the moisture is within an acceptable range. These shall be undertaken at a frequency of not less than 1 test per 50m³.

- (v) Where materials for Method compaction have a field moisture content outside of the range $OMC \pm 2\%$, reference shall be made to the appropriate compaction curves to validate whether the material is within a suitable range for compaction. Where outside of a reasonable range (to be determined by the Supervisor) the material shall be subject to End-Product compaction with further compaction testing nominated by the Supervisor, or shall be subject to wetting or drying as appropriate to adjust the moisture content.

10. Method compaction

- (i) Shall be undertaken as per SHW600 and the requirements of this Appendix;
- (ii) Compaction method will be dependent on the findings of the trial placement of fill as detailed in Appendix 6/1.
- (iii) Quality assurance testing shall be undertaken as per Table 6/4 of this Appendix.

11. End-Product compaction:

- (i) Compaction method and plant selection will be dependent on the outcome of the compaction trials as detailed in Appendix 6/1.
- (ii) Compaction validation shall be undertaken at the frequency given in Table 6/4.

Table 6/4 - Testing frequency for End-Product compaction validation and source quality assurance

Property	Minimum frequency	
	064B544/4/40	Type 1 Material
Grading (including hydrometer)	1 test per 500m ³ supplied.	1 test per 250m ³ supplied.
Atterberg Limits		
Moisture content	1 test per 250m ² (square metres) laid, up to a maximum of 5 per day per works area of compaction	1 test per 250m ² (square metres) laid, up to a maximum of 5 per day per works area of compaction
In situ dry density, air voids, and moisture content		
Laboratory maximum dry density and optimum moisture content	1 representative test per 5 in situ dry density/air voids/ moisture content tests (not to be combined from individual sample areas)	1 representative test per 5 in situ dry density/air voids/ moisture content tests (not to be combined from individual sample areas)
Chemical testing (pH, Sulfates, Chlorides)	1 suite per 500m ³ supplied.	1 suite per 500m ³ supplied.

- (iii) The rate of testing are contingent upon trial compactions being undertaken in accordance with 6/3 Cl. 8.
- (iv) Where the mean in situ dry density exceeds 98% compaction, the collective results shall only be acceptable if less than 20% of the number of test results fall beneath 95% compaction.
- (v) Where the mean in situ dry density is between 95% and 98% compaction, the collective results shall only be acceptable if less than 10% of the number of test results fall beneath 95% compaction.

12. Nuclear density gauges for compaction validation

- (i) The use of a nuclear density gauge is permitted subject to a calibration and provided that it is operated in direct transmission mode.
- (ii) The Contractor is required to provide the method and calibration data to the Designer prior to the use of the equipment on site.
- (iii) Nuclear density gauges shall be calibrated regularly and operated in accordance with BS1377: Part 9. The test shall be UKAS accredited.

13. Locations of excavations for foundations that are permitted to be battered and requirements for benching prior to backfilling and compaction

- (i) If the Contractor proposes to batter any excavations for foundations, he shall submit details to the Designer or Overseeing Organisation for agreement prior to the commencement of such works.

14. Requirements for benching or shaping to natural or existing earthworks slope faces to receive fill

- (i) Reprofiting of existing topography shall include stripping of vegetated subgrades prior to construction of new fill.
- (ii) Existing slopes or gradients at greater than 1V:8H shall be benching to receive fill. The exception to this is for fill being placed against the ISR slopes and concrete covered berms where benching is not to be carried out.
- (iii) Where smooth faced compaction plant is used, harrowing shall be employed at fill lift interfaces to not less than 50mm depth.

Appendix 6/5 – Geotextiles Used to Separate Earthworks Materials

1. A geotextile separator is to be used between the existing surface and any imported fill. The exception to this is in the location of the Type 1 berm in Sub-Area 4 through which benching of material is permitted.

2. The geotextile is to be a Terram 1000 or similar approved.
3. The geotextile is to be installed in accordance with the manufacturers recommendations.

Appendix 6/6 – Fill to Structures and Fill above Structural Foundations

1. Requirements and material classes for fill to structures and fill above structural foundations are shown on the relevant drawings.
2. Earthworks to support structures shall not be traversed by plant and vehicles once compaction has been completed to the design foundation level. Where adverse weather conditions are anticipated, the surface shall be protected or deepened where softened by water.
3. Prior to placement of columns at the design foundation level (or slab formation level, whichever is appropriate), the formation shall be subject to inspection by the Supervisor for any loose spots or deterioration of the surface. These shall be remediated using localised compaction at the Supervisor's direction. The Contractor shall keep records of the locations of areas requiring remediation for inclusion in record drawings.

Appendix 6/7 – Preparation and Surface Treatment of Formation

1. Any intense vegetation (trees, hedgerows, shrubs) that exists within the area of the works shall be stripped in accordance with project requirements/regulations.
2. Existing topsoil shall be removed in advance of the commencement of earthworks construction over the proposed footprint of the works and deposited in a stockpile(s) as per the requirements of this Specification and away from any acceptable material to be used for engineering fill. Any segregated sub-soils shall be set-aside for reuse as topsoil or landscape fill provided they meet the requirements of this specification.
3. Areas of prior excavation and replacement during Enabling Works shall be subject to specific proof rolling along any lines of excavation that may be susceptible to settlement. Compaction plant for this purpose shall be of width less than the backfilled trench, and of sufficient energy to identify areas of poor prior compaction. These areas shall be excavated and recompacted at the direction of the Supervisor. Any deleterious material shall be discarded.
4. Prior to placement of any fill, the formation shall be:
 - a. Firm (with a minimum undrained shear strength of 25kPa) or medium dense,
 - b. Dry and free from standing water,

- c. Free from cracks, voids debris and stones and any other deleterious material,
 - d. No irregularity shall exceed +/- 100mm over any 5m length of the formation.
5. The final 300mm of excavations to formation level shall be carried out immediately before placing the first layer of fill to prevent weathering of the contact surface.
6. Immediately prior to construction of the first layer of fill, the formation level shall be final graded to fill in all voids, or cracks, and then smooth-rolled to provide a sound foundation. Scarification shall still be necessary following a visual inspection to ensure bonding of the first layer with underlying ground.
7. Following completion of surface preparation, a visual inspection shall be undertaken by the Project Manager and/or Supervisor to confirm the overall suitability of the formation.
8. Once the formation has been exposed, the Contractor shall be responsible for maintaining it in the condition in which it was approved by the Project Manager. Exposed areas of formation should be kept to a minimum and should be covered quickly to avoid deterioration from adverse weather.
9. It shall be the responsibility of the Contractor to rectify any deterioration of the formation which occurs subsequent to the Project Manager's approval being given.
10. A level survey shall be undertaken on a 5m × 5m grid prior to construction of the first layer of earthworks to ensure that the formation surface is within the specified level tolerance.

5 Geo-environmental Requirements

The imported fill is to conform to specific requirements set out by Google / Argent. The testing and conformity of materials is provided in Appendix D.

6 Summary

This report provides the earthworks specification for the filling works at King's Cross Central Zone A which will enable the creation of a level platform on which a tented temporary theatre can be erected. The types of fill used are a natural quarried material which conforms to the Client's environmental requirements.

DRAFT

References

Draft

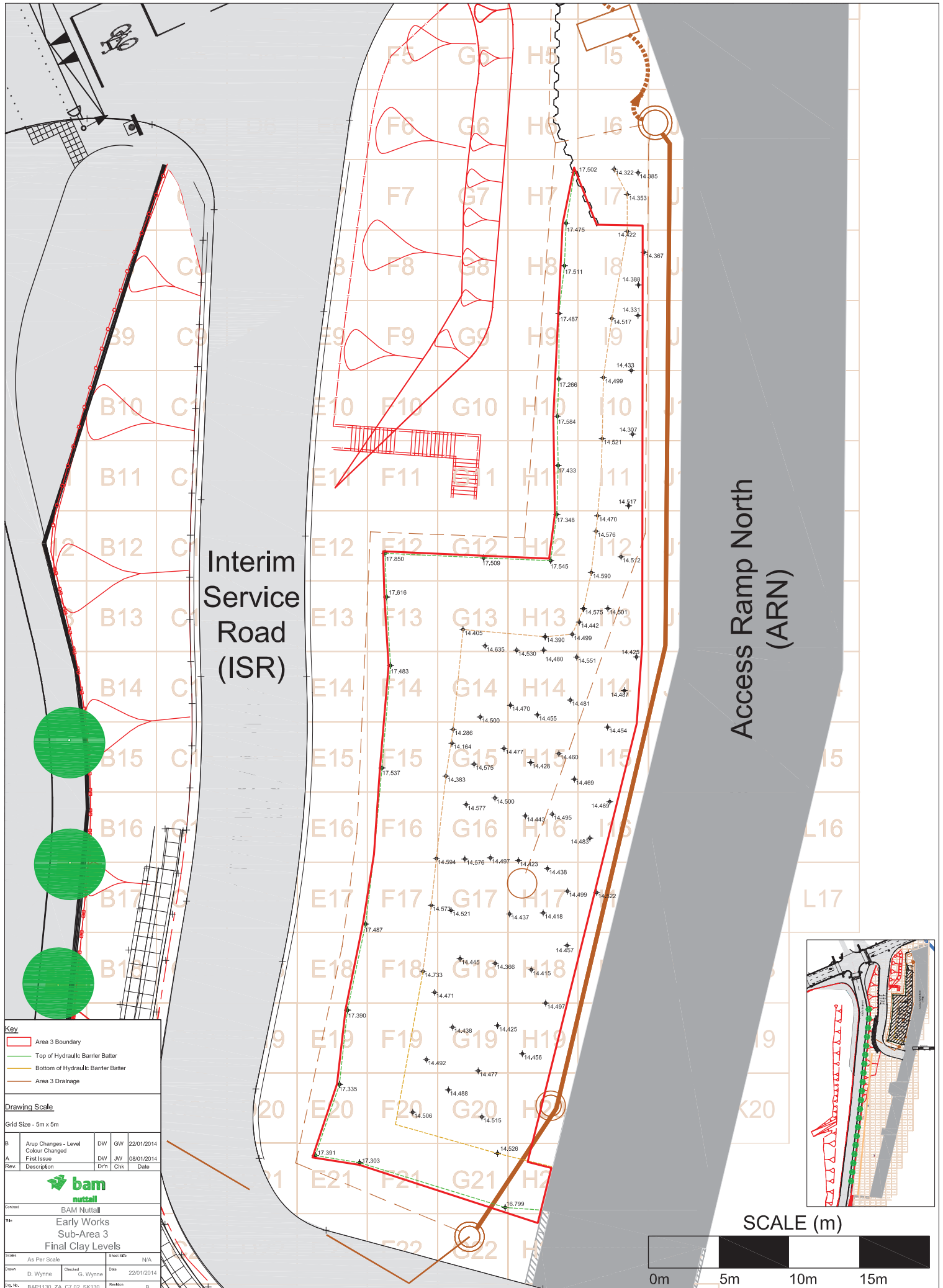
- [1] Highways Agency, Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks. *Accessible via the Highways Agency website.*

Draft

Appendix A

Current Site Levels

Draft



Interim Service Road (ISR)

Access Ramp North (ARN)

Key

- Area 3 Boundary
- Top of Hydraulic Barrier Batter
- Bottom of Hydraulic Barrier Batter
- Area 3 Drainage

Drawing Scale
Grid Size - 5m x 5m

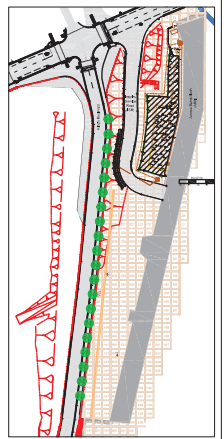
Rev.	Description	Drawn	Checked	Date
B	Anup Changes - Level Colour Changed	DW	GW	22/01/2014
A	First Issue	DW	JW	08/01/2014



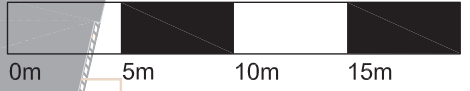
Contract: BAM Nuttall
Title: Early Works Sub-Area 3 Final Clay Levels

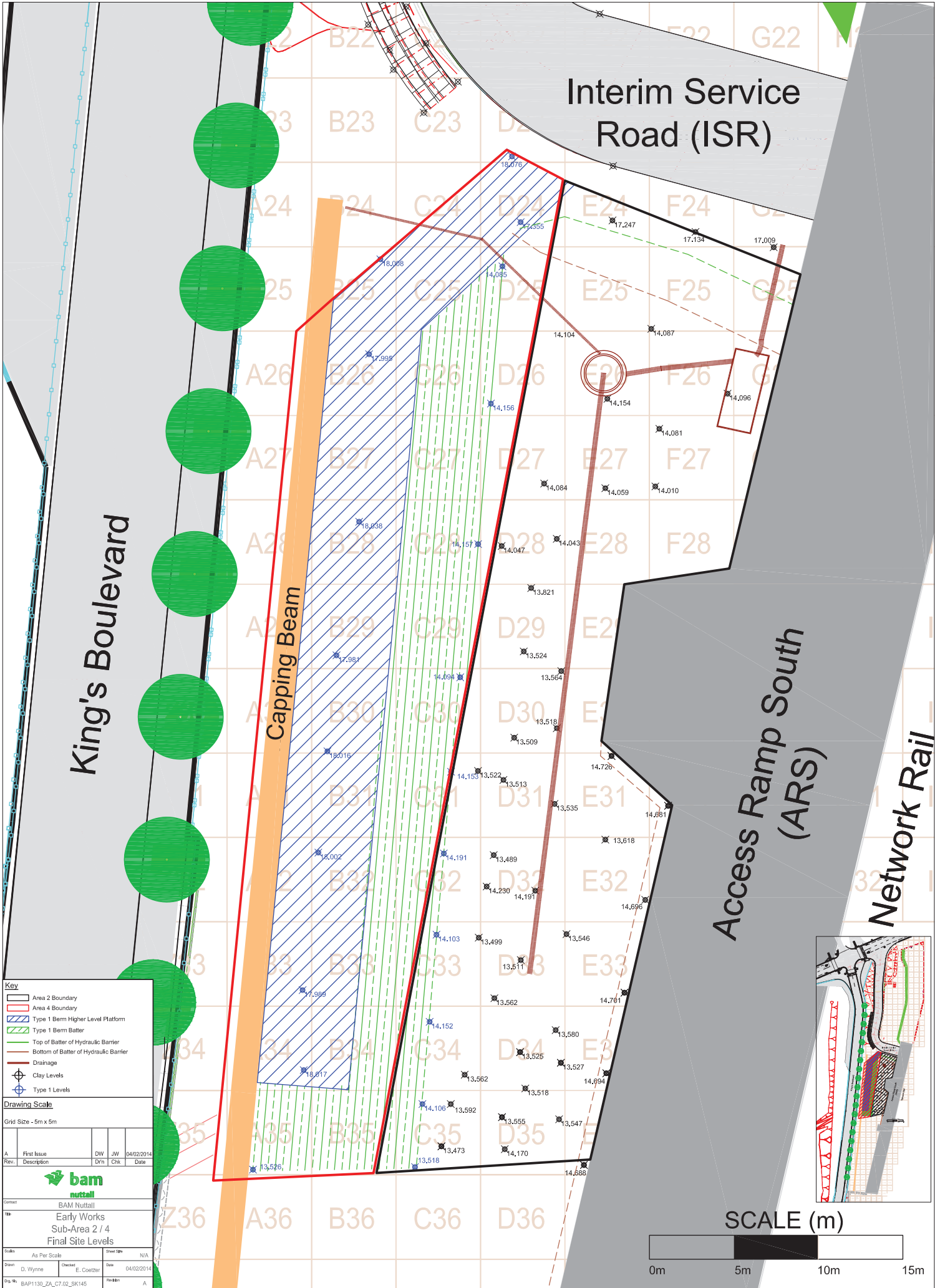
Drawn	As Per Scale	Checked	N/A
Drawn	D. Wynne	Checked	G. Wynne
Date	22/01/2014	Rev.	B

Proj. No.: BAP1130_ZA_C7.02_SK130



SCALE (m)





King's Boulevard

Interim Service Road (ISR)

Capping Beam

Access Ramp South (ARS)

Network Rail

Key

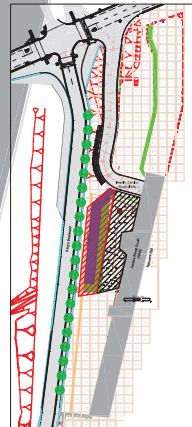
- Area 2 Boundary
- Area 4 Boundary
- Type 1 Berm Higher Level Platform
- Type 1 Berm Batter
- Top of Batter of Hydraulic Barrier
- Bottom of Batter of Hydraulic Barrier
- Drainage
- Clay Levels
- Type 1 Levels

Drawing Scale
Grid Size - 5m x 5m

Rev.	Description	DW	JW	Chk	Date
A	First Issue				04/02/2014

bam nuttall
BAM Nuttall
Early Works
Sub-Area 2 / 4
Final Site Levels

Scale: As Per Scales
Sheet Size: N/A
Drawn: D. Wynne
Checked: E. Coetzler
Date: 04/02/2014
Proj No: BAP1130_ZA_CT_02_SK145
Revision: A



SCALE (m)



Appendix B

Hanson Aggregates Material Data Sheet

Draft

Hanson Aggregates

General Output



GRADATION ANALYSIS TEST REPORT

for Product: 064B544/ 4/40 Gc90/15

Supplier/ source: 064/Whatley Quarry

Material type: BS EN 12620 Test method: Dry grading to BS EN 933-1

SAMPLE INFORMATION

Sampled/ tested

Thu 12 December 2013/ 16-12-13
at 1010 hrs

Sample number	SWE28369AGG	Ticket No.	-
Sample Origin	STOCK / RLO	Site/Client Address	-
Sampler	AC9008	Aggregate type	L
Your Sample Ref.	340659	Tag No.(Lab only)	751 / 407
Oven No.(Lab only)	23		

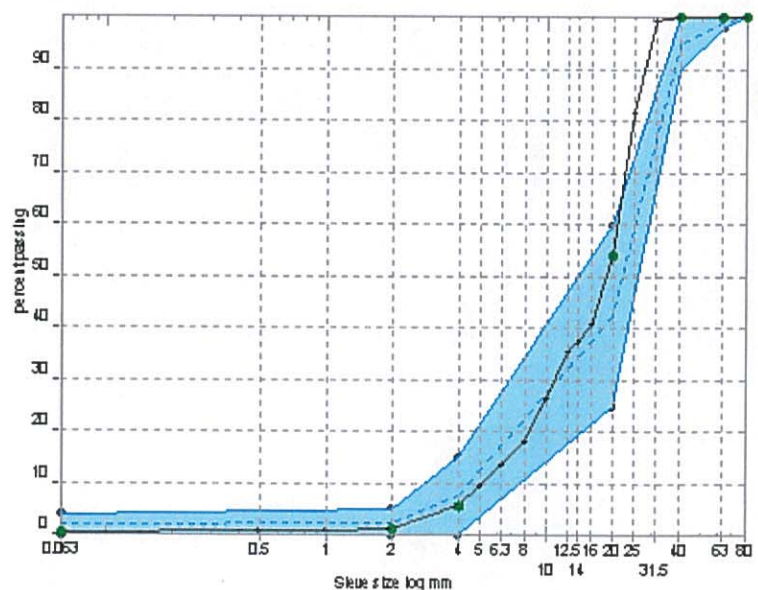
SAMPLE ANALYSIS

Sieve size	Percent passing	Specification limits	Complies ?
80mm	100	100 - 100	yes
63mm	100	98 - 100	yes
40mm	100	90 - 100	yes
31.5mm	99	-	-
25mm	81	-	-
20mm	54	25 - 60	yes
16mm	41	-	-
14mm	37	-	-
12.5mm	35	-	-
10mm	27	-	-
8mm	18	-	-
6.3mm	14	-	-
5mm	9	-	-
4mm	6	0 - 15	yes
2mm	1	0 - 5	yes
1mm	1	-	-
0.500mm	1	-	-
0.063mm	0.4	0.0 - 4.0	yes
Moisture content %	3.0	not specified	-
Flakiness index	no result	<=35	-

Parameters are evaluated to the accuracy of spec. limits

REMARKS

Compliance status ok
Category A of A-C includes secondary parameters



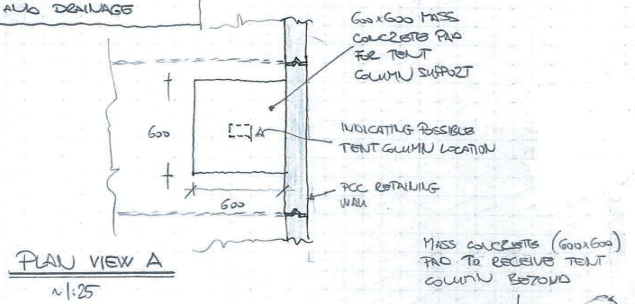
Signed _____ Date ____/____/2014

Appendix C

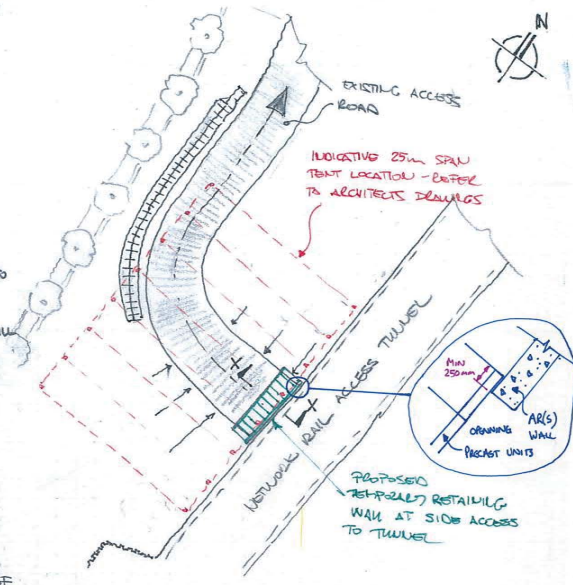
Temporary Retaining Wall Drawing

Draft

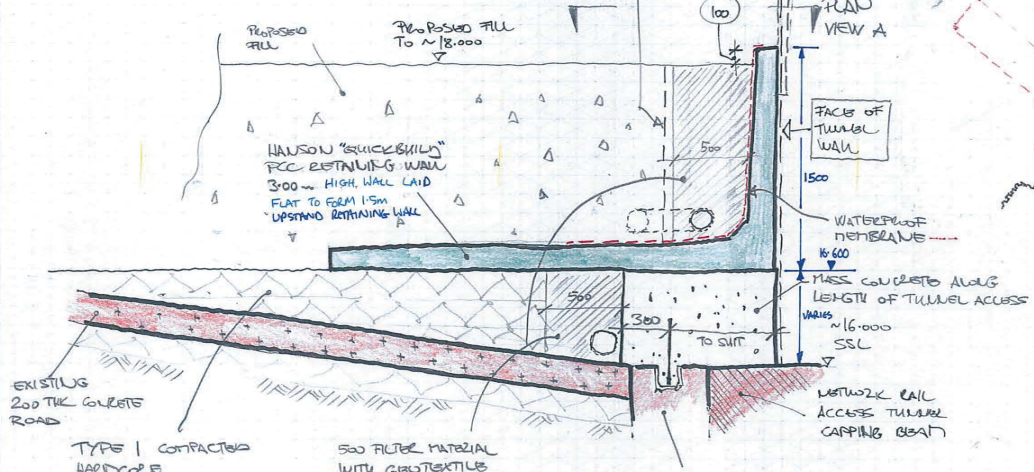
GENERAL NOTES:
 - REFER TO ARUP SPECIFICATIONS FOR FILL AND DRAINAGE



PLAN VIEW A
 ~ 1:25



SITE PLAN
 ~ 1:500



TYPICAL SECTION (X-X)
 ~ 1:25

PROPOSED RETAINING WALL DETAILS

MASS CONCRETE GRADU TO BE 11/1 GEN 3

ARUP		Axis Sheet
Sketch Title PROPOSED RETAINING WALL DET.		
Job Title RAILWAY CHILDREN		
Job No. 233634	Sketch No. SK-10	Rev.
Made by RB	Date 23/09/14	Chd. GCH

Appendix D

Environmental Testing Requirements

Draft

D1 Chemical Requirements

Samples of granular fill used to construct the raised platform shall be sampled and tested for the 'General Suite of Contaminants' as set out in Table A1 below.

Table A1 General Suite of Contaminants

Parameter	Accreditation	Laboratory Method
pH value	MCERTS	Potentiometric
Moisture Content	None	Gravimetric
Carbon (TOC)	MCERTS	Titrimetric
Loss on Ignition@ 450oC	MCERTS	Gravimetric
Stone Content	None	Gravimetric
Elemental Sulphur	None	GCMS
Sulphate (as SO4) - Water Soluble (2:1)	MCERTS	ICP-OES
Chloride - Water Soluble (2:1)	MCERTS	Titrimetric
Asbestos Screen	ISO17025	Stereobinocular Microscope
Ammonium (NH4+)	MCERTS	ISE
Particle size distribution	BS1377.	Sub-contracted
Arsenic	MCERTS	ICP-OES
Beryllium	MCERTS	ICP-OES
Boron	MCERTS	ICP-OES
Barium	MCERTS	ICP-OES
Cadmium	MCERTS	ICP-OES
Chromium	MCERTS	ICP-OES
Copper	MCERTS	ICP-OES
Lead	MCERTS	ICP-OES
Mercury	MCERTS	ICP-OES
Nickel	MCERTS	ICP-OES
Anitmony	MCERTS	ICP-OES
Selenium	MCERTS	ICP-OES
Vanadium	MCERTS	ICP-OES
Zinc	MCERTS	ICP-OES
Hexavalent chromium	MCERTS	Skalar CFA
Phenols (total)	MCERTS (Monohydric)	HPLC
Cyanide total	MCERTS	Skalar CFA
Total Petroleum Hydrocarbons (TPH CWG) with BTEX and MTBE	MCERTS	GC/MS-
Speciated & Total Polyaromatic Hydrocarbons (USEPA 16)	MCERTS	GC/MS

A minimum of 1 sample shall be tested for each source and the results supplied prior to any placement of fill at the site from that source. Additional sampling and testing shall be at a minimum rate of 1 sample/1,000m³ placed.

The results of the testing shall be compared to the Zone A Remediation Validation Criteria given in Table below (where a limiting criteria is given). Samples shall be

deemed acceptable if the measured concentration is less than the criteria in Table A2. If any results exceed the validation criteria the source material shall not be used unless a qualitative/semi-quantitative risk assessment acceptable to the Environ (UK) Limited is provided by the Contractor.

Table A2 Remediation Validation Criteria

Parameter	Units	Validation Criteria
Inorganics		
Total Cyanide	mg/kg	78
BTEX		
Benzene	mg/kg	28
Toluene	mg/kg	200
Ethylbenzene	mg/kg	200
Xylenes (total)	mg/kg	200
Petroleum Hydrocarbons		
TPH Aliphatic EC5-EC6	mg/kg	3,380
TPH Aliphatic >EC6-EC8	mg/kg	1440 ^(a)
TPH Aliphatic >EC8-EC10	mg/kg	780 ^(a)
TPH Aliphatic >EC10-EC12	mg/kg	480 ^(a)
TPH Aliphatic >EC12-EC16	mg/kg	240 ^(a)
TPH Aliphatic >EC16-EC35	mg/kg	6500 ^(b)
TPH Aliphatic >EC35-EC44	mg/kg	6500 ^(b)
TPH Aromatic >EC8-EC10	mg/kg	3670
TPH Aromatic >EC10-EC12	mg/kg	3620 ^(a)
TPH Aromatic >EC12-EC16	mg/kg	1680 ^(a)
TPH Aromatic >EC16-EC21	mg/kg	6500 ^(b)
TPH Aromatic >EC21-EC35	mg/kg	6500 ^(b)
TPH Aromatic >EC35-EC44	mg/kg	6500 ^(b)
Polyaromatic Hydrocarbons		
Acenaphthene	mg/kg	567 ^(a)
Acenaphthylene	mg/kg	855 ^(a)
Anthracene	mg/kg	2000 ^(b)
Benz(a)anthracene	mg/kg	90
Benzo(a)pyrene	mg/kg	14
Benzo(b)fluoranthene	mg/kg	100
Benzo(k)fluoranthene	mg/kg	140
Benzo(ghi)perylene	mg/kg	650
Chrysene	mg/kg	135
Dibenzo(ah)anthracene	mg/kg	13
Indeno(123-cd)pyrene	mg/kg	60
Fluoranthene	mg/kg	2000 ^(b)
Fluorene	mg/kg	308 ^(a)
Naphthalene	mg/kg	204
Phenanthrene	mg/kg	2000 ^(b)
Pyrene		2000 ^(b)
Total PAH	mg/kg	2,000 ^(b)
Phenols		
Phenol	mg/kg	500
(a) Ten times saturation limit		
(b) Value capped based on professional judgement (visual and olfactory issues)		

The Contractor must allow sufficient time for the sampling, analysis and decision making process required to meet the design objectives. A standard turnaround for the chemical analysis of soil samples is ten working days. A contract must be set up in advance with a UKAS accredited laboratory.

D2 Laboratory Standards

The Contractor shall provide the following information in advance of the Works for approval by the ENVIRON (UK) LIMITED.

- Details on the laboratories accreditation to ISO 17025.
- Confirmation that the soil analysis specified for the verification of the remediation will be undertaken in accordance with MCERTS. If the soils analysis cannot be undertaken in accordance with MCERTS the reason why should be stated.
- State the analyses for which the laboratory holds UKAS accreditation for in respect to the detection limits stated in **Error! Reference source not found.**
- Details on the laboratory procedures for quantifying analytical errors, eg running replicate samples, standards and blanks.
- Details of whether the analytical methods are fully validated and documented with assigned uncertainty values.
- Samples shall be kept cold (below a maximum of 6°C) and transferred to the lab within 24 hours of sampling, unless agreed otherwise by the ENVIRON (UK) LIMITED.
- Samples shall be received at the laboratory and analysed within the holding times required for each analysis, as specified by the laboratory. Samples must be received by the laboratory within the temperature range specified by the laboratory. Holding times and temperature on receipt by the laboratory must be reported to the ENVIRON (UK) LIMITED within 1 week of samples being obtained. Results from deviant samples (i.e. samples held outside the required holding times or received at temperatures outside the required temperature range) will not be accepted and shall be re-sampled on site.

Any asbestos analysis shall be undertaken in accordance with the methodology presented in **Error! Reference source not found.**

All chemical analyses shall be undertaken to the method detection limits specified in **Error! Reference source not found.**

D3 Waste and Materials Management

No material classified as a 'waste' shall be imported onto the Site, either for use in temporary works or for incorporation into the permanent platform works.

Where the CONTRACTOR intends to or is required to discard soils, materials or waters/sludges that are removed from the Site, they are classified as a waste under the Waste Framework Directive.

Wastes that require disposal or treatment off-site shall undergo waste classification assessment and waste acceptance criteria assessment, as necessary, to determine the appropriate disposal route and facility.

Records of wastes sent off site shall be kept on site for inclusion within the Verification Report.

The CONTRACTOR shall prepare a Site Waste Management Plan (SWMP) for the works, and shall:

- Obtain relevant information from subcontractors and waste receivers;
- Ensure that subcontractors are appropriately licensed to carry out waste classification and handling activities;
- Ensure that all appropriate permits are in place to transfer waste from the Site;
- Keep the SWMP on site during the project;
- Keep the SWMP up-to-date;
- Ensure that other contractors know where the SWMP is kept;
- Allow other contractors and the client access to the SWMP during the project; and
- Keep the SWMP for two years after the completion of the project.

The SWMP is required to contain the following information:

- The types of waste removed from the site;
- The identity of the person who removed the waste and their waste carrier registration number;
- A description of the wastes;
- Details of the site that the waste was taken to; and
- Details of the Environmental Permit or exemption held by the site where the material is taken.

D4 Verification

D4.1 Verification Report Detailed Data Requirements

The Contractor shall be required to keep detailed records for inclusion in a Verification Report. Examples of the information required are given below:

- Material movement and material import inspection records.
- Waste Disposal Transfer Notes and summary.
- Haulage contractor licences.
- Copies of Environmental Permits and confirmation of their surrender.
- Raw chemical and geotechnical laboratory and field testing results.

- Details of permits held and confirmation that they have been surrendered.
- Results of ambient monitoring.
- Supervisor's weekly reports.
- Site photographs of all activities.
- 'As built' drawings of fill, retaining walls, and drainage, to include depths, materials etc.

D4.2 Data Management

All the required data for the Verification Report shall be stored electronically. The final data management system shall be agreed with ENVIRON (UK) LIMITED and Arup. The Contractor shall provide a nominated document controller to manage the data and provide responses to any data queries from ENVIRON (UK) LIMITED and Arup.

D5 Laboratory Method Detection Limits

Parameter	Detection level
Soil Samples - metals	
Arsenic	1 mg/kg
Cadmium	0.5 mg/kg
Chromium	10 mg/kg
Chromium - hexavalent	5 mg/kg
Copper	10 mg/kg
Lead	10 mg/kg
Mercury	0.5 mg/kg
Nickel	10 mg/kg
Selenium	0.5 mg/kg
Zinc	10 mg/kg
Antimony	0.1 mg/kg
Barium	1 mg/kg
Beryllium	1 mg/kg
Iron	10 mg/kg
Manganese	5 mg/kg
Molybdenum	0.5 mg/kg
Vanadium	0.5 mg/kg
Organotins (dibutyltin/tributyl-tin/tetrabutyltin/triphenyl-tin)	0.1mg/kg
Soil Samples - non metal inorganics	
Asbestos (identification and quantification) refer to method A1 below	0.001%w/w
Cyanide - total	5 mg/kg
Cyanide - thiocyanates*	5 mg/kg
pH	0.1 units
Sulphate - total	200 mg SO4/kg
Sulphate - 2:1 extract	0.1 g SO4/l

Free Sulphur	100 mg/kg
Sulphides	10 mg/kg
Boron (water soluble)	0.5 mg/kg
Chloride	5 mg/kg
Fluoride	0.1 mg/kg
Soil Samples - organics	
Phenols - total	1 mg/kg
Phenols - monohydric*	1 mg/kg
Mineral oils (by IR)	50 mg/kg
Polyaromatic Hydrocarbons (USEPA Priority 16 PAHs speciated and totalled by CGMS)	0.2 mg/kg
Total Petroleum Hydrocarbons* (C8 to C40 by GC FID)	50 mg/kg
Diesel Range Organics (C10 to C26)	50 mg/kg
Petrol Range Organics (C5 to C10)	1 mg/kg
BTEX (by GCMS)	0.05 mg/kg
Polychlorinated Biphenyls	0.005 mg/kg
Semi-Volatile Hydrocarbons (by GC-MS with speciation of compounds)	0.01 mg/kg
Volatile Hydrocarbons (by GC-MS with speciation of compounds)	0.01 mg/kg
TPH by GC-FID with aliphatic and aromatic class separation and carbon banding Aliphatic - C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Aromatic - C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44	10 mg/kg
Total Organic Carbon (ASTM D2974-87)	0.1% w/w
Loss On Ignition	0.1% w/w
Herbicides including atrazine and simazine	0.01mg/kg
Organ-chlorine pesticides including 'drins'	0.01mg/kg
Water Samples - general properties	
pH value	0.1 pH units
BOD	2 mg O2/l
COD	10 mg O2/l
Alkalinity	2 mg/l
Hardness	2 mg/l
Water Samples - metals	
Arsenic	5 µg As/l
Cadmium	1 µg Cd/l
Chromium	5 µg Cr/l
Chromium - hexavalent	10 µg Cr/l
Copper	10 µg Cu/l
Lead	4 µg Pb/l
Mercury	0.1 µg Hg/l
Nickel	10 µg Ni/l
Selenium	5 µg Se/l
Zinc	8 µg Zn/l
Calcium	10 µg Ca/l

Iron	10 µg Fe/l
Magnesium	30 µg Mg/l
Manganese	10 µg Mn/l
Sodium	10 µg Na/l
Potassium	10 µg K/l
Antimony	5 µg /l
Beryllium	5 µg /l
Vanadium	5 µg /l
Organotins (dibutyltin/tributyl-tin/tetrabutyltin/triphenyl-tin)	0.02 µg /l
Water Samples - non metal inorganics	
Ammoniacal nitrogen	0.01 mg N/l
Chlorides	20 mg Cl/l
Cyanide - total	30 µg CN/l
Cyanide - ferro and ferri-cyanide*	30 µg CN/l
Cyanide - free*	30 µg CN/l
Cyanide - thiocyanates*	30 µg CN/l
Sulphates	2000 µg SO ₄ /l
Sulphides	200 µg S/l
Nitrate	0.3 mg/l
Nitrite	0.01 mg/l
Water Samples - organics	
Phenols - total (monohydric)	20 µg C ₆ H ₅ OH/l
Phenols - specialised by HPLC*	0.5 µg C ₆ H ₅ OH/l
Mineral Oils by IR	100 µg/l
Total Petroleum Hydrocarbons (C ₈ to C ₄₀ by GC-FID)	50 µg/l
Diesel Range Organics (C ₁₀ to C ₂₆ by GC-FID)	50 µg/l
Petrol Range Organics (C ₅ to C ₁₀ by GC-FID)	50 µg/l
Volatile Organics (by GC-MS with speciation)	1 µg/l
Semi-Volatile Organics (by GC-MS with speciation)	1 µg/l
BTEX	1 µg/l
Polyaromatic Hydrocarbons (16 USEPA by GCMS)	0.05 µg PAH/l
TPH by GC-FID with aliphatic and aromatic class separation and carbon banding	50 µg/l
Herbicides including atrazine and simazine	0.01 µg/l
Organ-chlorine pesticides including 'drins'	0.01 µg/l

D6 Asbestos Analysis Method A1

D6.1 Initial Stereo-binocular/PLM - Screening Stage

Each sample is thoroughly mixed, spread across a clean plastic tray and examined visually for the presence of asbestos. Any obvious asbestos material (asbestos cement, pieces of loose lagging etc.) is removed by hand picking and set aside for weighing.

The samples in which asbestos is detected are dried and weighed along with any materials removed to determine the proportion of asbestos in the original soil sample. The asbestos content of the asbestos containing materials (ACM) is determined by comparison with standard reference materials and reference to MDHS 100 (HSE, 2001).

A representative sub-sample of approximately for each soil is selected by coning and quartering. These samples are analysed visually under stereo binocular microscope and by Polarised Light Microscopy (PLM) using the method described in HSG 248 (HSE, 2005).

D6.2 Quantitative Phase Contrast Microscopy Assessment

Approximately 1gram of each sample is transferred to a clean 500ml conical flask and 300mls of filtered distilled water added. The sample/water mixture shall be agitated for 20 seconds and allowed to stand for ten seconds. After sedimentation time, aliquots shall be removed from just below the liquid surface and deposited onto a 0.8µm pore size blank tested membrane filter. The filters shall be carefully dried, cleared and fixed onto glass microscope slides using the acetone/triacetin method described in HSG 248 (HSE, 2005).

Two microscope slides shall be produced from each sample and the estimated mass percentage calculated as the mean of the two results for each sample.

The Phase Contrast Microscopy (PCM), shall be based closely on HSG 248 (HSE, 2005) including reagents, equipment and filter clearing and mounting. A specific Walton-Beckett graticule shall be used for fibre sizing.

A countable fibre for the purpose of estimating the asbestos mass percentage is defined as an amphibole asbestos or chrysotile fibre. Non-asbestos fibres shall not also be counted.

The fibre dimensions (length and diameter [µm]), number of ends falling in the graticule and fibre identity shall be recorded for each individual countable fibre. Measurements recorded to the nearest 5µm for length and to the nearest 0.5µm for diameter, up to a maximum of 5µm. The identity of each fibre shall be recorded as amphibole or chrysotile where possible. Fibre identification shall be based on morphology and optical properties determined by PLM.

The overall mass percentage of asbestos is given by the formula below:

$$A W (\Sigma V p^A + \Sigma V p^C) \times 100 / a N q S$$

pA = average density of amphibole asbestos (3.0 x 10⁻⁶µg µm⁻³)

pc = density of chrysotile (2.5 x 10⁻⁶µg µm⁻³)

A = area of filter (mm²)

V = volume of fibre (µm³)

a = area of graticule (mm²)

W = volume of water in suspension (ml)

N = number of graticules evaluated

S = weight of soil in suspension (µg)

q = aliquot on filter (ml)

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