Northern Gas Networks

Gas Holder Site Backfilling

Lot 3 - Holder Voids Holders

Birkshall (No. 1 & 2) Bradford

Canal Road (No. 5 & 6) Bradford

Keighley (No. 1 & 3) Keighley

Huddersfield (No. 4)

1.0 Project Introduction

Backfilling Brick / Concrete Tanks – Lot 3 (West Yorkshire of Network)

The following information details the steps to be taken in order for a safe and secure backfilling operation of seven below ground tanks following the demolition of the below ground holders at Birkshall and Canal Road – Bradford, Keighley and Huddersfield, West Yorkshire.

As demonstrated in the sketches included in Appendix 7, the gas holder tanks are suspected to be raised in the centre with a typical characteristic 'dumpling' structure. The profile of the dumplings in each tank are currently unknown and cannot be confirmed until demolition and dewatering has completed. As such it is currently not possible to confirm the void volume in each tank, however these have been estimated in Appendix 7 and total approximately 79,400m^3. This volume equates to a material tonnage of approximately **135,000 metric tonnes (t)** (assuming 1.7 t/m^3) or **159,000 t** (assuming 2.0 t/m^3) required to infill the tanks to a level surface flush with the top of the tank wall and excluding 'domed' clay cap for rain water run off. Two separate values have been used to represent differing material conditions (dry to wet respectively). For the purposes of this backfill operation an additional allowance of approximately **10,000 to 10,500 t** of clay should be included for crowning the three in-filled tank voids with a 'centre' 300 mm depth of clay.

The seven gas holders are shown in the aerial photograph below:

Note: Holder Void is Elswick Site and is for illustration purposes only.

2.0 Access to Holder Voids

Post holder demolition phase, stone access ramps will be left in situ to ensure safe and reliable access for earthworks excavators onto the "dumpling", backfilling operations and access / egress (inclusive of emergency) of designated and authorised personnel.

Those access ramps were required to be constructed in 6F5 grade material to guarantee suitable compaction to ensure the ramps can withstand the ground loading pressures exerted by the machines without the risk as ramp collapse or break up. The 6F5 material will be compliant with NGN Backfill Material Chemical Validation Criteria (Hard Granular Materials) as detailed within this document.

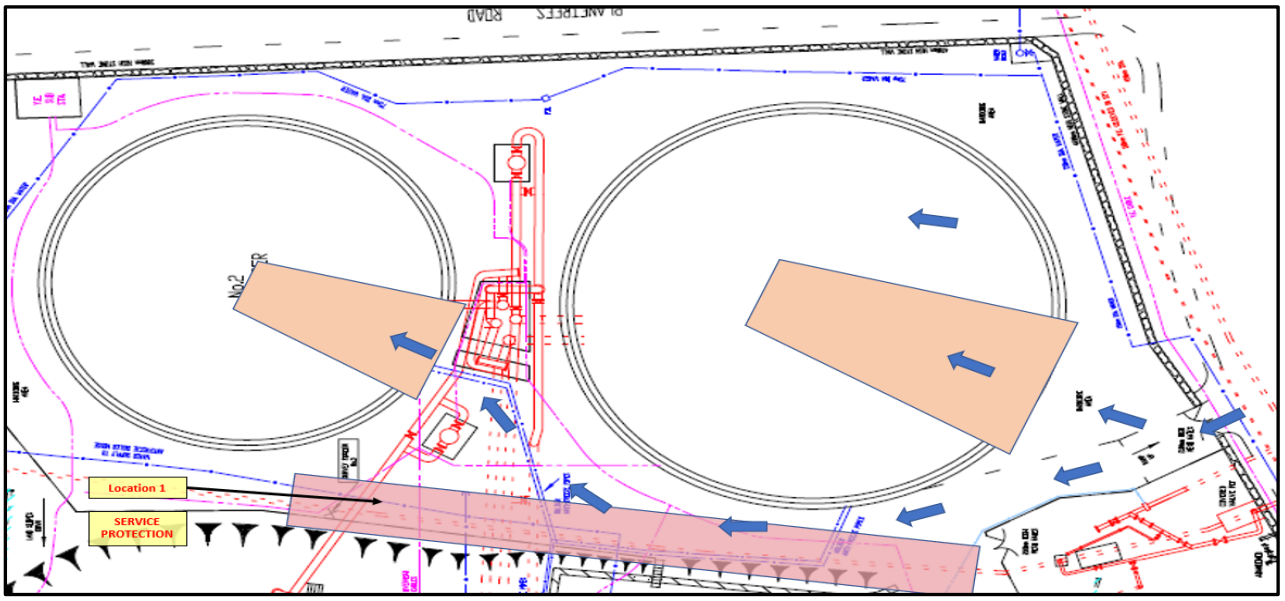
During the demolition phases of the works, a suitable temporary works design for the ramps will be required to be submitted to the ***Client*** for acceptance. Equally at the point of removal of the final 'lift' sections situated behind the ramp, a secondary access /egress ramp will need to be installed prior to de-constructing the original ramp for removal of the remaining tank wall sections. The same requirements apply regarding construction material and temporary works designs. Any deviation from this will require approval from the NGN Project Engineer.

Any water that has collected within the tank following completion of the cleaning phase, including ponded water accumulating prior to the backfilling phase, will require removal prior to the commencement of backfill operations. This water will be required to be removed by tanker for offsite disposal to an appropriately licenced waste management facility under duty of care. Alternatively the water can be sampled and if the results show that the water is of acceptable quality (with reference to published UK water quality standards) then it can be disposed of via the local drainage system (providing the accepting drainage system authority has provided consent), or over land via natural filtration at a suitable location and dependent upon volume via 6" Blige Pumps (to be supplied by the Main Works Contractor (***MWC***)). The ***MWC*** would be responsible for obtaining the necessary consent to permit disposal of water to the local drainage network if such a consent is not already held by NGN. Disposal to land would require the consent of the NGN Project Engineer and Environment Team.

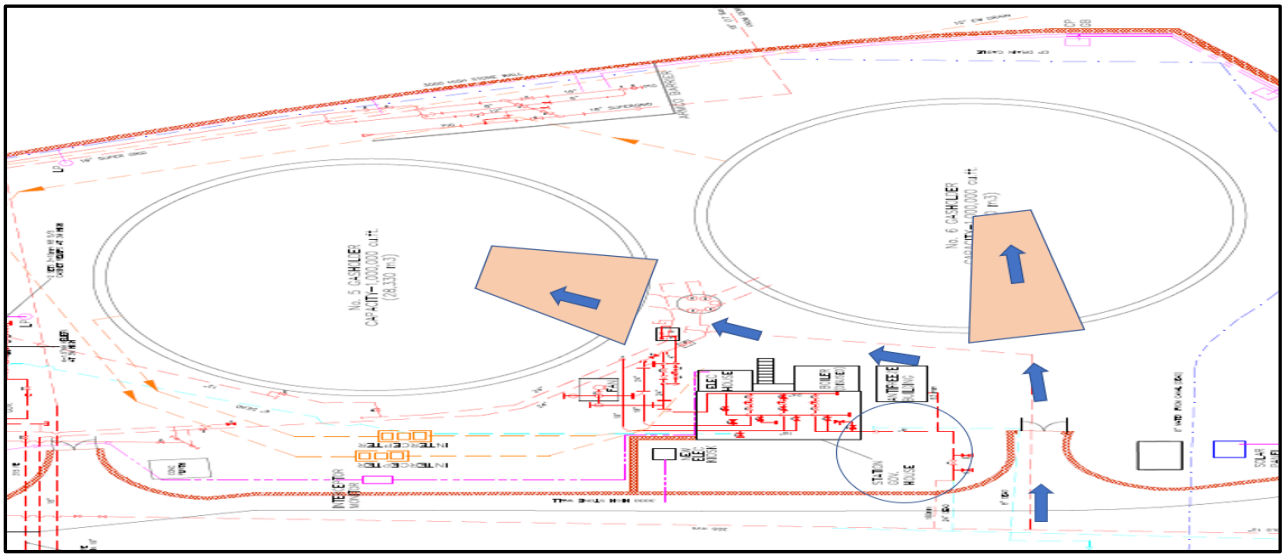
The minimum chemical analysis suite for samples of water for consideration for infiltration to NGN land is: metals, TPH CWG by GC-MS, BTEX by GC-MS, 16 PAHs by GC-MS, total cyanide, total phenol, sulphate, pH and suspended solids.

The chemical analysis suite for samples of water for consideration for discharge to the local drainage system are as per the requirements of the relevant authority (for example Yorkshire Water).

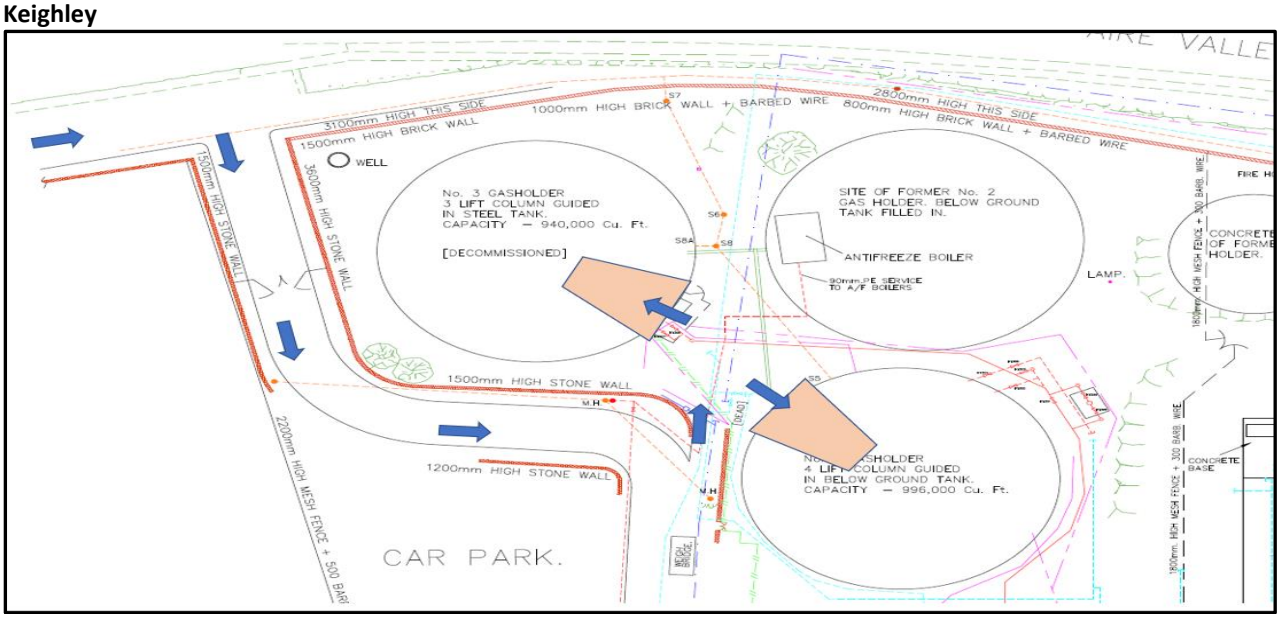
Birkshall - Bradford



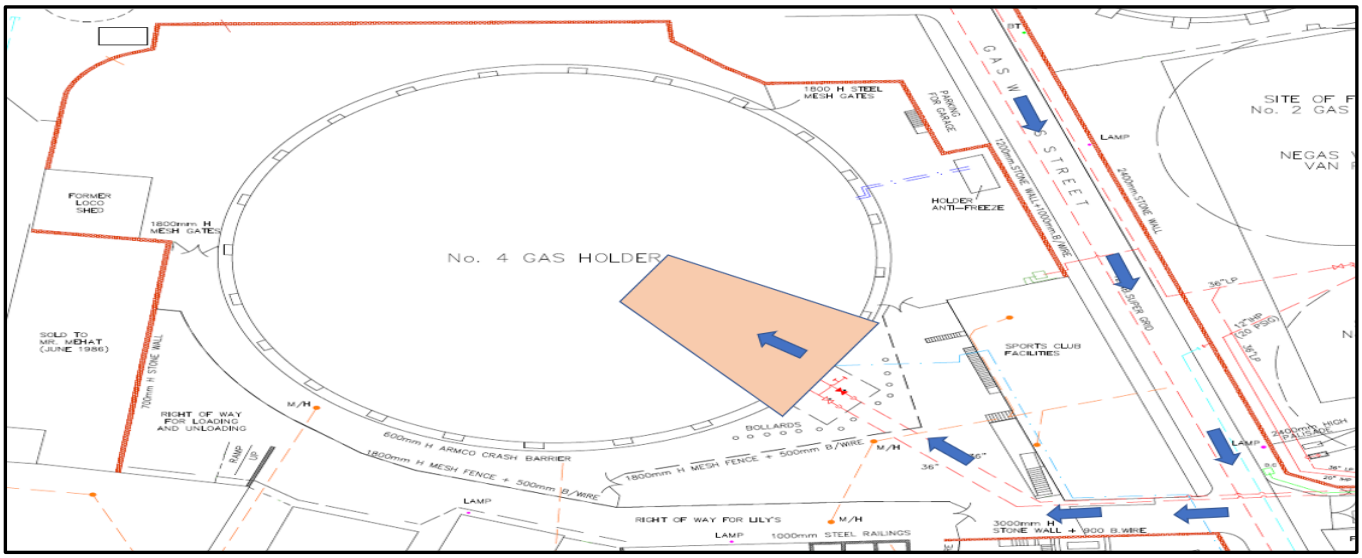
Canal Road - Bradford



Keighley



Huddersfield



Appendix 1 – Site Layout Plan illustrating routes to holder ramps and minimum service protection required for 20t "Tipper Wagons".

3.0 Site restrictions

The site still contains live buried gas pipelines with operational equipment located within site buildings. The ***MWC*** must refer to site plans and utility drawings in order to determine if plant and equipment can negotiate the site without crossing over live pipelines. If this is not possible then detailed investigations must be undertaken to support a temporary works design for protection measures / temporary haul road construction that maybe necessary to distribute ground loadings exerted by plant and machinery to ensure the risk of damage to buried apparatus is reduced to low levels as is reasonably practicable.

Appendix 1 above illustrates the minimum protection measures that will be required with respect to tipper wagon crossing points.

4.0 Site Preliminaries

Requirements for Permits and provision of ***MWC's*** risk assessments and method statements (RAMS) and competency are detailed within the accompanying Works Information Summary for applicable Gas Holder Demolition Works. RAMS for the backfilling phase should pay particular attention to the safe access and egress of personnel and plant/equipment into the tank void, notably when adjacent to the dumpling and the specific inclusion of any live (above or below ground) gas pipelines.

The ***Client*** requires the ***MWC*** to provide installation of fill material under a ***Zero Volume Contract*** (see the accompanying Works Information Summary for the applicable site, Gas Holder Demolition Works) in order to import suitable material to site to backfill the four holder tank voids.

4.1 Compliance with CL: AIRE Waste Code of Practice

All necessary requirements under the CL: AIRE Waste Code of Practice specifications associated with the backfilling works must be met by the ***MWC*** and these will be vetted / approved by the ***Client's*** Environmental Team and Project Engineer before proceeding. The ***MWC*** is responsible for preparation of the Material Management Plan and Verification Report, including provision of the relevant Qualified Persons declarations, in association with the backfilling operation as required under the CL: AIRE Waste Code of Practice.

4.2 Site Husbandry

Any areas disturbed by the works surrounding the gasholder should receive a 70mm thick layer of 25mm single size washed gravel chippings or suitable surfacing to match existing surrounding surfaces and including provision of any shortfalls of material) on a layer of 'Northern Gas Networks Ltd' approved geotextile membrane over subsoil or fill. Prior to installing any membranes, the subsoil should be treated with a 'Northern Gas Networks Ltd' approved weed killer.

Any sections of security fencing that have been disturbed are to be replaced to match existing in accordance with 'Northern Gas Networks Ltd' civil specification 'NGN/SP/CE/9:2011' (Security Fencing).

Any decommissioned pipe runs that are to be left after the demolition work have been completed are to be grout filled and capped with a 'high flow' workable pumped concrete mixture to the satisfaction of the ***Client***. Client Project Manager will ensure this work has been completed during the demolition phase of the works.

Any temporary constructed haul roads and / or raised surfaces are to be de-constructed and material cleared from site on completion of the works. If it is suspected (or known) that any material having been cleared from site may be contaminated then it should be disposed of as contaminated waste to an appropriately licenced waste management facility under duty of care, and evidence of disposal provided to the Client in the form of Waste Transfer and Consignment Notes clearly stating the material, quantity and route of disposal.

5.0 Fill Material Acceptability Criteria and Approval Process

The ***MWC*** is responsible for identifying potentially appropriate sources of fill material to the ***Client*** for consideration and approval. All fill materials must fully comply with the requirements of both the NGN bulk earthworks specification (see Section 5.1 below) and the NGN Backfill Material Chemical Validation Criteria (see Section 5.2 below) in order to be approved for use by NGN. Filling of a particular material type / source must not proceed without written approval from the ***Client***.

In summary, the holder tank voids are required to be filled with materials which comply with the ***Client*** geotechnical and chemical validation requirements (as detailed below) until level with the top of the holder tank wall. On the final compacted fill layer the overall diameter of the tank is to be sealed with minimum 300mm of clay and capped with the final layer of suitable backfill material rolled to produce a 'dome' to finish at ground level, overlapping the tank wall to ensure any water run off flows to land rather than back into the holder tank bund.

5.1 Fill Material Geotechnical Acceptability Criteria

All fill materials must comply with the requirements of the NGN specification for *Bulk Earthworks for the Infilling of Gas Holder Tank Voids and Associated Structures* contained in Appendix 11 of this document. Geotechnical testing requirements and frequencies are identified in the specification.

The ***MWC*** is responsible for the provision of all material geotechnical testing certificates to confirm compliance with the above specification. In accordance with the specification, NGN must be provided with at least five working days to review and approve geotechnical material samples and test results.

5.2 Fill Material Chemical Acceptability Criteria

The chemical acceptability criteria for gas holder backfill materials have been selected with reference to the current site use, potential future site use, and with reference to the environmental site setting, in particular the potential contaminant risks to human health and controlled waters. Site environmental setting information is provided in Appendix 9.

5.2.1 Background to Selected Chemical Acceptability Criteria

As referenced within Appendix 9, all four sites are situated within a commercial / industrial setting and currently used for gas distribution, but could be amenable to future residential development. As such, fill material chemical acceptability criteria has been selected to maximise future potential for residential development of the site, or at least not prevent or hinder future residential site use.

As referenced within Appendix 9, the four sites are in low to low/moderate sensitivity environmental settings with respect to controlled waters receptors given the natural ground conditions, limited potential connectivity with watercourses, existing groundwater quality and absence of local sensitive groundwater abstractions. Critically the fill materials will be substantially contained by the existing holder tank structures (which are designed to be water tight and will not be punctured during filling) with a finishing cap of low permeability clay material to limit rainwater ingress..

Based on the above, it is assessed that the infilled gas holder tanks will pose no significant pollutant linkages to controlled waters once infilled and capped and as such it is considered appropriate for the fill material chemical acceptability criteria to be protective of human health only.

5.2.2 Chemical Acceptability Criteria and Validation Requirements

In order to be considered acceptable for use, all backfill material must comply with the following chemical criteria:

- Free from visual contamination, asbestos containing materials, macadam and detritus;
- Free from contaminated odours;
- Be tested for the contaminants identified in *Appendix 10 Table 1* (soft soil materials) or *Appendix 10 Table 2* (hard materials) at the identified testing interval(s) with all contaminants present in concentrations no greater than the acceptability criteria specified in *Table 1 or Table 2 of Appendix 10*.

The ***MWC*** must identify the proposed material source/stockpile to be used for backfilling purposes. The ***MWC*** must also provide evidence / details of the *Feeder Sites* from where the material originated from if the proposed source/stockpile is made up of several *Donor Sites* and resides at one central location.

Validation sampling of the proposed backfill material will be completed by the ***Client***, with these results being the authoritative dataset to determine material compliance with the NGN Chemical Fill Material Chemical Acceptability Criteria. The ***MWC*** must make the material available to the ***Client*** to enable collection of the necessary chemical validation samples at the material source. The ***MWC*** must provide safe access to the entire material stockpile, where relevant, and have provision of an excavator (as necessary to be able to dig into the stockpile in order to take suitable sample from within rather than just surface sampling only).

Nominally the ***Client*** will collect 50% of the necessary samples at the material source. Chemical analysis will be commissioned by the ***Client*** on a 10-working day turnaround. Within 3 working days of the receipt of the chemical analysis results, the ***Client*** will confirm in writing to the ***MWC*** whether the material is considered acceptable as backfill material with respect to the chemical acceptability

criteria. Assuming the material is approved, the remainder of the chemical validation samples will be collected periodically as the material is delivered to site and scheduled for analysis, in order to confirm material consistency.

The collection of additional or duplicate samples by the ***MWC*** is permissible, for example for initial material characterisation, however the ***Client*** dataset is the authoritative dataset for determining material compliance.

5.2.4 Site Inspection of Fill Materials

Import of fill materials will be subject to visual and olfactory checks by the full time NGN Site Assurance Officer on site prior to giving authority to "tip" the load into the applicable void. This person will have the authority to reject loads to ensure that unsuitable materials are not accepted. Should a load be rejected, this will be recorded with photographic evidence and the ***MWC*** informed immediately to ensure that the reason for rejection is investigated to avoid additional unsuitable loads being brought to site. Rejected loads will be returned to a suitably permitted waste disposal or treatment facility.

6.0 Fill Methodology

All filling operations, including material selection and testing requirements, must comply with the requirements of the NGN specification for *Bulk Earthworks for the Infilling of Gas Holder Tank Voids and Associated Structures* contained in Appendix 11 of this document.

In addition, compaction of the layers of backfill in Keighley x 2 and Huddersfield x 1 is of critical importance due to the requirement for crane access to the centre of the holder to remove the framework once backfilling is completed. Because of this, the compaction of the backfill must be sufficient to achieve a **minimum** point-load capability of 23 tons per metre square within the holder footprint.

7.1 Validation Requirements – Verification Report

In accordance with the requirement of the CL: AIRE Waste Code of Practice, following completion of the holder tank filling works a verification report is required to be completed by the ***MWC***. The verification report should include the following information as a minimum:

- A description of the actual work carried out, with dates.
- A photographic record of the work.
- Earthworks drawings.
- Materials accepted.
- A summary of chemical and geotechnical test results, including any failures and any remedial measures undertaken.
- Testing Certificates.
- Compaction Results.
- Complete set of weighbridge tickets / consignment notes for fill materials delivered to site.
- Final site conditions following completion of works.
- A statement that the works have been undertaken in accordance with the aims of the filling requirements and this specification, and that the site is considered "Suitable for use".

This report will be retained on file for inspection by any interested parties and will be available on request.

8.1 Typical Key Plant / Machinery for Filling Works

- 360 40t Excavator within tank
- 360 30t Excavator external tank for loading dumper
- 10te Dumper
- Vibrating Roller (when necessary – monitored throughout the backfill progress)
- Road Sweeper – Brush (To ensure site roads & public highway to / from site are kept clean).

This is an Indicative list but NOT Limited to.

9.0 Site Working Hours

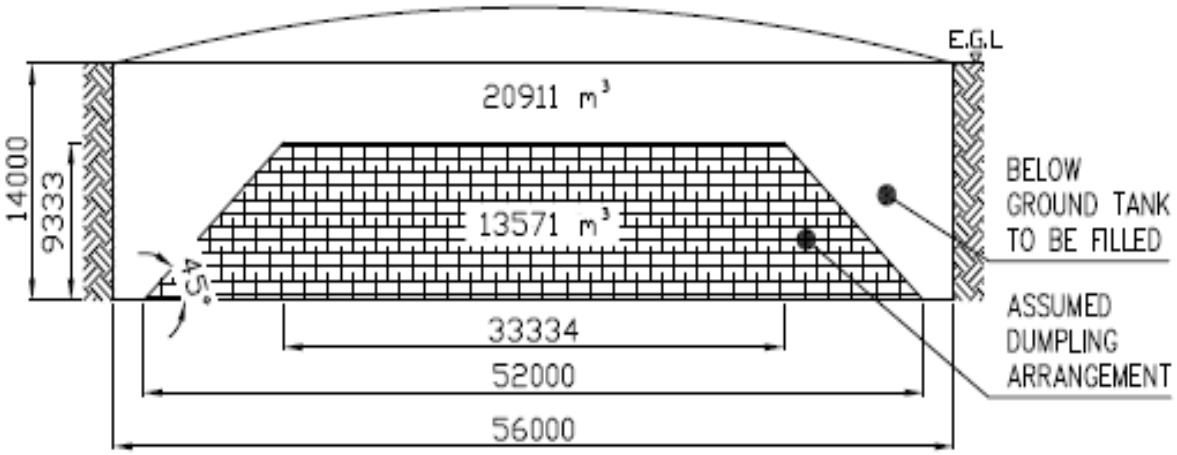
Site working hours are restricted to those below unless agreed otherwise in accordance with the conditions of the contract and acceptance by Project Engineer. However, the perceived impact on surround Stakeholders in the immediate area of the works may influence or reduce the duration of the daily working hours.

Monday – Friday 08:00 to 17:00

10.0 SHE

Refer to the Works Information Summary for the relevant Gas Holder Demolition Works for safety, health and environmental requirements relevant to the filling of the gas holder tanks.

Appendix 7a **– Estimated Volumes**



ASSUMED EXISTING HOLDER '5' SECTION C–C

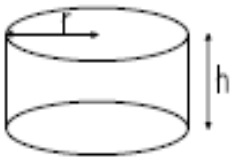
1:500

Total 'below-ground' holder volume (cylinder) [m³]

$V = \Pi \times r^2 \times h$

$h = 14M$

$V = \Pi \times 28^2 \times 14m = \underline{34482m^3}$



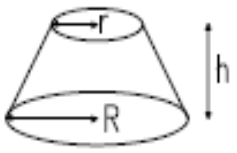
Volume of dumpling (frustum) [m³]

$V = \frac{\Pi \times h}{3} \times (R^2 + Rr + r^2)$

$V = \frac{\Pi \times 9.33}{3} \times (26^2 + (26 \times 16.7) + 16.7^2)$

$V = 9.77 \times (676 + 434 + 279)$

$V = \underline{13571m^3}$



EST. FILL VOLUME REQUIRED = $34482m^3 - 13571m^3 = \underline{20911m^3}$

NOTE

THE FIGURE OF $10606m^3$ IS ONLY AN ESTIMATE SINCE THE ACTUAL DUMPLING SIZE WILL BE UNKNOWN UNTIL DEMOLITION COMMENCES AND INVESTIGATION CAN TAKE PLACE

FILL REQUIRED FOR GASHOLDER '5' VOID

Note: The above sketches are for illustration purposes to indicate how the following volumes were calculated.

Appendix 7b – Estimated Volumes

Holder	North / Yorks	Above / Below	Tank diameter (ft)	Tank diameter (m)	Tank radius	Tank depth (ft)	Volume ft (total)	Volume ft (assuming dumpling 1/3 of volume)	Volume (m)	Order Demolished	Complete
Huddersfield	Yorks	Below	220	67.056	110.00	42.5	1615773.50	1066410.51	30197.33		No
Birkshall No 1	Yorks	Below	182.5	55.626	91.25	30.5	797942.81	526642.26	14912.82		No
Birkshall No 2	Yorks	Below	152.8	46.57344	76.40	31.75	582286.37	384309.01	10882.40		No
Keighley No 3	Yorks	Below	132	40.2336	66.00	27	369536.90	243894.36	6906.31		No
Keighley No 1	Yorks	Below	122	37.1856	61.00	25	292284.55	192907.80	5462.53		No
Canal Road No 5	Yorks	Below	122	37.1856	61.00	24.5	286438.86	189049.65	5353.28		No
Canal Road No 6	Yorks	Below	122	37.1856	61.00	24.5	286438.86	189049.65	5353.28		No

Appendix 8: Volume details:

Material Bulk Density Table.

Material	Density at the Borrow 10^3 (kg/m^3)	Bulking (Swell) Factor (%)
Basalt	2.4 - 3.1	75 - 80
Clay	1.8 - 2.6	20 - 40
Dolomite	2.8	50 - 60
Earth		20 - 30
Gneiss	2.69	75 - 80
Granite	2.6 - 2.8	75 - 80
Gravel, dry	1.80	20 - 30
Gravel, wet	2.00	20 - 30
Limestone	2.7 -2.8	75 - 80
Loam		15 - 25
Quartz	2.65	75 - 80
Rock		40 - 80
Sand, dry	1.60	20 - 30
Sand, wet	1.95	20 - 30
Sandstone	2.1 - 2.4	75 - 80
Slate	2.6 - 3.3	85 - 90
Soil	1.2 - 1.6	20 - 30

Appendix 9: Environmental Backfill Requirements Environmental Site Setting

Birkshall, Bradford

ASPECT	DESCRIPTION AND SENSITIVITY RATING
Site Description and Environs	The site comprises a gas distribution infrastructure site within a wider industrial/commercial setting. The site features three decommissioned gas holders with ancillary buildings and pipework. Other gas distribution infrastructure is located in the west and south of the site. Historically the current NGN site formed part of a town gas production ('gasworks') and storage site which extended offsite to the west. The site adjoined immediately to the north and west by metal recycling facilities and waste transfer stations. Commercial properties to the south beyond Peace Street. Commercial and residential properties are present to the east beyond Planetrees Road. **Low sensitivity**
Geology	British Geological Survey (BGS) mapping (Ref 1) identifies natural ground conditions beneath the site to comprise Glacial Till over Pennine Lower Coal Measures. Detailed ground investigation completed at the site as detailed in Ref 2 has identified the following sequence of ground conditions beneath the site: • Made ground: typically dark brown and black clayey gravelly sand and sandy gravelly clay proven to a maximum depth of 2.6 metres below ground level (m bgl); over • Glacial Till: sandy clay with gravel of limestone, mudstone and coal to a maximum depth of 2.7m bgl; over • Bedrock: sequences of strong yellow brown sandstone, weak dark grey thinly laminated mudstone, and coal encountered from 0.25m bgl to a maximum proven depth of 11m bgl. The in-ground tanks of Gas Holders No.1 and No.2 are c.9.5m deep meaning they are likely founded on the bedrock. NGN archive information identifies the below ground gas holder tanks to be of brick construction and they are anticipated to have been constructed with a puddle clay surround to the tank walls for water tightness. **Low/moderate sensitivity**
Hydrogeology (Ref 2)	The natural superficial deposits are classified as Non-productive Strata. The underlying bedrock is classified as a Secondary A Aquifer. There are no licensed groundwater abstractions within 500m of the site. The site is not located within a Groundwater Source Protection Zone (SPZ). Groundwater monitoring identified groundwater in the bedrock beneath the site at depths ranging between 1.3m bgl and 6.6m bgl. Groundwater was interpreted to be likely to be flowing northwesterly. The gas holders are located on part of a former gasworks and in an area of wider historical

	and current industrial usage. Ref 2 identifies that hazardous and non-hazardous substances have been identified in groundwater beneath the site, interpreted to be associated with former gasworks activities. **Low/moderate sensitivity**
Hydrology	The closest watercourse to the site is Bradford Beck approximately 250m north-west of the site and is noted as heavily modified (Ref 2). **Low sensitivity**
References	Ref 1: BGS geology viewer: http://mapapps.bgs.ac.uk/geologyofbritain3d/ Ref 2: Phase 2 Land Quality Assessment, Planetrees Road, Birkshall, Bradford; Hydrock; Final, January 2015, R/14652b/001

Canal Road, Bradford

ASPECT	DESCRIPTION AND SENSITIVITY RATING
Site Description and Environs	The site comprises a gas distribution infrastructure site within a wider industrial/commercial setting. The site features two decommissioned gas holders with ancillary buildings and pipework. Other gas distribution infrastructure is located in the north and east of the site. Historically the current NGN site formed part of a town gas production ('gasworks') and storage site which extended offsite to the west, beyond the existing Canal Road. The site is adjoined immediately to the north by a car showroom. Further car showrooms are present to the west (beyond Canal Street) and south (beyond Kings Road). Industrial/commercial premises are present to the east of the site. **Low sensitivity**
Geology	British Geological Survey (BGS) mapping (Ref 1) identifies natural ground conditions beneath the site to comprise alluvium and Diamicton Till, with potentially Glacial Till beneath, over Pennine Lower Coal Measures. Detailed ground investigation completed at the site as detailed in Ref 2 has identified the following sequence of ground conditions beneath the site: • Made ground: typically sandy gravel to a maximum depth of 1.5 m bgl over soft to firm gravelly clay identified to 3.2m bgl (base not proven); over • Alluvium: sandy gravelly clay to a maximum depth of 5.0m bgl (base not proven). The depth to the bedrock beneath the site has not been established. Ref 2 identifies that bedrock (mudstone and sandstone) has locally been identified from 14m deep. The in-ground tanks of Gas Holders No.5 and No.6 are c.7.5m deep meaning they are likely founded in cohesive superficial deposits (alluvium and potential Diamicton Till and Glacial Till). NGN archive information identifies the below ground gas holder tanks to be of brick construction and they are anticipated to have been constructed with a puddle clay surround to the tank walls for water tightness. **Low sensitivity**

Hydrogeology (Ref 2)	The natural alluvium superficial deposits are classified as a Secondary A Aquifer, with the till classified as Unproductive Strata. There are no licensed groundwater abstractions from the superficial deposits within 1km of the site. The underlying bedrock is classified as a Secondary A Aquifer. There is one recorded active licensed groundwater abstractions within 1km of the site, located 150m from the site for 'general use'. The site is not located within a Groundwater Source Protection Zone (SPZ). Groundwater monitoring identified groundwater in the alluvium superficial deposits beneath the site at depths ranging between 0.9m bgl and 2.4m bgl. Groundwater was interpreted to be likely to be flowing southwesterly. The gas holders are located on part of a former gasworks and in an area of wider historical and current industrial usage. Ref 2 identifies that hazardous and non-hazardous substances have been identified in groundwater beneath the site, interpreted to be associated with former gasworks activities. **Low/moderate sensitivity**
Hydrology	The closest watercourse to the site is Bradford Beck approximately 50m west of the site, being culverted under a car showroom (Ref 2). The watercourse is noted to be in an open channel to the northwest and southwest. **Low/moderate sensitivity**
References	Ref 1: BGS geology viewer: http://mapapps.bgs.ac.uk/geologyofbritain3d/ Ref 2: Phase 2 Land Quality Assessment, Canal Road, Bradford; Grontmij; Final, January 2016, 116262/JW/150730

Keighley

ASPECT	DESCRIPTION AND SENSITIVITY RATING
Site Description and Environs	The site comprises a gas distribution infrastructure site within a wider mixed industrial/commercial setting split into two separate compounds. The northernmost compound site features two decommissioned gas holders with surrounding ancillary buildings and pipework. The southernmost compound features pressure reduction equipment and ancillary buildings and pipework. Historically the current NGN compounds formed part of a town gas production ('gasworks') and storage site which extended offsite to the east. To the north of the site is the A650 dual carriageway with sports fields beyond. To the east of the site is vacant, remediated former gasworks land. To the south of the site is a railway line on an embankment above the level of the site. To the west of the site is a light industrial estate. **Low sensitivity**
Geology	British Geological Survey (BGS) mapping (Ref 1 and Ref 2) identifies natural ground conditions beneath the site to comprise alluvial fan deposits over bedrock of the Millstone Grit Group. Detailed ground investigation completed on site as detailed in Ref 2 has identified the following sequence of ground conditions beneath the site: • Made ground: Sandy gravelly clay and gravelly sand to a maximum depth of 1.2m bgl; over • Superficial Deposits (Alluvial Fan Deposits): Sandy gravelly clay to 3.25m bgl over interbedded gravelly sand and sandy gravel proven to a maximum of 5m bgl (base not proven) beneath the northernmost compound, with slightly clayey slightly sandy gravel and silty sand present beneath the southernmost compound to 11.5m bgl (base not proven). The depth to bedrock beneath the site has not been established. The in-ground tanks of Gas Holders No.1 and No.3 are c.7.6m and 8.2m deep respectively, meaning they are likely founded in interbedded granular and cohesive superficial deposits (Alluvial Fan Deposits). NGN archive information identifies the below ground tanks of Gas Holders No.1 and No.3 to be of cast iron and steel construction and they are anticipated to have been constructed with a puddle clay surround to the tank walls for water tightness. **Low/moderate sensitivity**

Hydrogeology (Refs 2 and 3)	The Alluvial Fan Deposits are classified as a Secondary A Aquifer. There are no recorded active licensed groundwater abstractions within 500m of the site (Ref 3). The underlying Millstone Grit Group bedrock is classified as a Secondary A Aquifer. There are no recorded active licensed groundwater abstractions within 500m of the site (Ref 3). The site does not lie within a Source Protection Zone (SPZ). Previous ground investigation identified groundwater in the superficial deposits at 6m to 7m bgl (Ref 2). The gas holders are located on part of a former gasworks and in an area of wider historical and current industrial usage. Ref 2 identifies that hazardous and non-hazardous substances have been identified in groundwater beneath the site, interpreted to be associated with former gasworks activities. **Low/moderate sensitivity**
Hydrology	The nearest surface watercourse is the River Aire, located 250m northeast of the site (Ref 2). There are no licenced surface water abstractions within 500m of the site (Ref 3). **Low sensitivity**
References	Ref 1: BGS geology viewer: http://mapapps.bgs.ac.uk/geologyofbritain3d/ Ref 2: Phase 2 Land Quality Assessment, Gasworks Road, Keighley; Sweco; Final, January 2017, 117792/21/160628 Ref 3: Data Review, Gasworks Road, Keighley; Grontmij; Final, November 2015, 116262/JW/150612

Huddersfield

ASPECT	DESCRIPTION AND SENSITIVITY RATING
Site Description and Environs	The site comprises a gas distribution infrastructure site within a wider mixed industrial/commercial setting. The site features a decommissioned gas holder with surrounding ancillary buildings and pipework, including a large building used as a materials store. Historically the current NGN compounds formed part of a town gas production ('gasworks') and storage site which extended offsite to the south beyond Gasworks Street. To the north of the site are commercial/industrial units, with a car dealership to the east. Immediately to the south is a social club and gym fronting on to Gasworks Road (public highway), with an NGN pressure reduction compound and vacant, remediated former gasworks land beyond. To the west is a car park and industrial units, with the Huddersfield Broad Canal beyond (approximately 50m from the site). **Low sensitivity**
Geology	British Geological Survey (BGS) mapping (Ref 1 and Ref 2) identifies natural ground conditions beneath the site to comprise alluvium over bedrock of the Pennine Lower Coal Measures Formation. Detailed ground investigation completed on site (gas holder station) as detailed in Ref 2 has identified the following sequence of ground conditions beneath the site: • Made ground: clays, sands and gravels to a maximum depth of 5.9m bgl; over • Superficial Deposits (Alluvium): Stiff silty clay to 7.50m bgl (base not proven). The depth to bedrock beneath the site has not been established. Locally depth to bedrock (mudstone) has been established as 11.9m bgl with granular deposits (gravels and cobbles) encountered overlying the mudstone (Ref 2). The in-ground tank of Gas Holder No.4 is c.12.8m deep, meaning that the tank is potentially founded on bedrock. NGN archive information identifies the below ground tanks of Gas Holder No.4 to be of reinforced concrete construction and they are anticipated to have been constructed with a puddle clay surround to the tank walls for water tightness. **Low/moderate sensitivity**

Hydrogeology (Ref 2)	The Alluvium is classified as a Secondary A Aquifer. The underlying Pennine Lower Coal Measures Formation bedrock is classified as a Secondary A Aquifer. There are several recorded active licensed groundwater abstractions within 150 to 250m of the site for process and cooling water, however they abstract from Millstone Grit bedrock, not the Pennine Lower Coal Measures Formation (Ref 2). The site does not lie within a Source Protection Zone (SPZ). Previous ground investigation identified seepages of groundwater in the superficial deposits at 3m bgl (Ref 2). The gas holders are located on part of a former gasworks and in an area of wider historical and current industrial usage which is anticipated to have impacted local groundwater quality. **Low/moderate sensitivity**
Hydrology	The nearest surface water feature is the Huddersfield Broad Canal located c.50m west of the site. It is considered unlikely that the canal will be in continuity with groundwater. The River Colne is located c.150m east of the site (Ref 2). There is a licenced surface water abstraction c.150m east of the site for general industry/cooling (Ref 2). **Low/moderate sensitivity**
References	Ref 1: BGS geology viewer: http://mapapps.bgs.ac.uk/geologyofbritain3d/ Ref 2: Land Quality Data Review, Leeds Road, Huddersfield; WSP Parsons Brinckerhoff, Final, March 2016, 70017188

Appendix 10 Table 1: Backfill Material Chemical Acceptability Criteria (Soft Soil Materials)

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
Description	No visual or olfactory indications of contamination, including no macadam/asphalt or asbestos containing materials			All material
Asbestos	No detectable asbestos fibres or asbestos containing materials to a laboratory limit of detection of <0.001% w/w.			1 in 500m3 and min. 3 no. samples per source
Total mercury	1.2	Lowest of mercury species (S4UL)	N/A	1 in 500m3 and min. 3 no. samples per source
Selenium	250	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Arsenic	37	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Nickel	180	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Cadmium	11	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Beryllium	1.7	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Boron	290	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Chromium (III)	910	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Chromium (VI)	6	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Copper	240	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Lead	200	C4SL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Vanadium	410	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Zinc	3700	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Free Cyanide	32	ATRISK	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzene*	0.087	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Toluene*	130	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Ethylbenzene*	47	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Total Xylenes*	56	Minimum of S4UL xylene bands	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
0-xylene*	60	S4UL	Residential with plant uptake	Only samples where total xylenes exceeds threshold
m-xylene*	59	S4UL	Residential with plant uptake	Only samples where total xylenes exceeds threshold
p-xylene*	56	S4UL	Residential with plant uptake	Only samples where total xylenes exceeds threshold
Phenol	280	CIEH/LQM	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Dioxins	0.008	SGV	Residential with plant uptake	No - only if suspected
Aliphatic EC 5-6*	42	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >6-8*	100	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >8-10*	27	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >10-12*	130	S4UL	N/A	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >12-16*	1100	S4UL	N/A	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >16-35*	65000	S4UL	N/A	1 in 500m3 and min. 3 no. samples per source
Aliphatic EC >35-44*	65000	S4UL	N/A	1 in 500m3 and min. 3 no. samples per source
Aromatic EC 5-7 (benzene)*	70	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >7-8 (toluene)*	130	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >8-10*	34	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >10-12*	74	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >12-16*	140	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >16-21*	260	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >21-35*	1100	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Aromatic EC >35-44*	1100	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Acenaphthene*	210	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source

Acenaphthylene*	170	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
Anthracene*	2400	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzo(a)anthracene*	7.2	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzo(a)pyrene*	2.2	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzo(b)fluoranthene *	2.6	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzo(ghi)perylene*	320	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Benzo(k)fluoranthene *	77	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Chrysene*	15	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Dibenzo(ah)anthracene*	0.24	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Fluoranthene*	280	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Fluorene*	170	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Indeno(123-cd)pyrene*	27	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Naphthalene*	2.3	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Phenanthrene*	95	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
Pyrene*	620	S4UL	Residential with plant uptake	1 in 500m3 and min. 3 no. samples per source
1,2-Dichloroethane	0.0071	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1,1-Trichloroethane	8.8	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1,2,2-Tetrachloroethane	1.6	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1,1,2-Tetrachloroethane	1.2	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Tetrachloroethene	0.18	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Tetrachloromethane	0.026	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Trichloroethene	0.016	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
Trichloromethane	0.91	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Vinyl Chloride	0.00064	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
2,4,6-Trinitrotoluene	1.6	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
alpha-Hexachlorocyclohexanes	0.23	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
beta-Hexachlorocyclohexanes	0.085	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
gamma-Hexachlorocyclohexanes	0.06	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Chlorobenzene	0.46	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2-Dichlorobenzene	23	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,3-Dichlorobenzene	0.4	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,4-Dichlorobenzene	61	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,3-Trichlorobenzene	1.5	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,4-Trichlorobenzene	2.6	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,3,5-Trichlorobenzene	0.33	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,3,4-tetrachlorobenzne	15	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,3,5-tetrachlorobenzne	0.66	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,4,5-tetrachlorobenzne	0.33	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Pentachlorobenzene	5.8	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Hexachlorobenzene	1.8	Vapour saturation limit	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Phenol	280	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Chlorophenols (**except pentachlorophenol)**	0.87	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
Pentachlorophenol	0.22	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Carbon Disulphide	0.14	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Hexachloro-1,3-Butadiene	0.29	S4UL	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1,2 Trichloroethane	0.6	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1-Dichloroethane	2.4	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,1-Dichloroethene	0.23	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2,4-Trimethylbenzene	0.35	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
1,2-Dichloropropane	0.024	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
2,4-Dimethylphenol	19	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
2,4-Dinitrotoluene	1.5	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
2,6-Dinitrotoluene	0.78	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
2-Chloronaphthalene	3.7	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Biphenyl	66	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Bis (2-ethylhexyl) phthalate	280	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Bromobenzene	0.87	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Bromodichloromethane	0.016	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Bromoform	2.8	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Butyl benzyl phthalate	1400	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Chloroethane	8.3	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Chloromethane	0.0083	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

Substance	Backfill Material Acceptability Criteria (mg/kg)	Source	Land Use Scenario	Analysis Frequency
Cis 1,2 Dichloroethene	0.11	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Dichloromethane	0.58	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Diethyl Phthalate	120	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Di-*n*-butyl phthalate	13	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Di-*n*-octyl phthalate	2300	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Hexachloroethane	0.20	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Isopropylbenzene	11	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Methyl *tert*-butyl ether	49	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Propylbenzene	34	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Styrene	8.1	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Total Cresols (2-, 3- and 4-methylphenol)	80	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Trans 1,2 Dichloroethene	0.19	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source
Tributyl tin oxide	0.25	EIC	Residential with plant uptake	1 in 1000m3 and minimum of three samples per source

* Analysis strictly by GC-MS methodology

Appendix 10 Table 2: Backfill Material Chemical Acceptability Criteria (Hard Granular Materials)

Substance	Backfill Material Acceptability Criteria	Analysis Frequency
Description	No visual or olfactory indications of contamination, including no macadam/asphalt or asbestos containing materials. As a minimum, the material must be accompanied by recent (<6 months old) laboratory test certificates demonstrating compliance with the relevant material grading and characterisation requirements as provided in the Specification for Highways Works (Series 600) and NGN specification for Bulk Earthworks for the Infilling of Gas Holder Tank Voids and Associated Structures contained in Appendix 11.	All material As per NGN specification for *Bulk Earthworks for the Infilling of Gas Holder Tank Voids and Associated Structures* contained in Appendix 11
Asbestos	No detectable asbestos fibres or asbestos containing materials to a laboratory limit of detection of <0.001% w/w.	1 in 500m3 and min. 3 no. samples per source