Newcastle City Council
Property Services
Civic Centre
Newcastle Upon Tyne
NE1 8PP

Former Tyne Brewery

Sites 1, 2 and 3

Contaminated Land Strategy

July 2009

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Contaminated Land Strategy

Issue and Revision Record

Rev	Date	Originator	Checker	Approver	Description
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Executive Summary

1.0 Introduction
Mott MacDonald Ltd has been commissioned by Newcastle City Council to produce a Contaminated Land Strategy for the former Tyne Brewery Site, bringing together all available data to produce a comprehensive strategy for the site, in support of its future re-development.

2.0 Scope
Work undertaken includes the review of existing desk study and ground investigation data; the use of chemical testing data to produce a site specific Contaminated Land Strategy to address contamination risks relating to a variety of end uses; the identification of remediation / mitigation options where appropriate; and the identification of validation testing requirements across the site. The site was divided into three parts for the purposes of investigation – Site 1, Site 2 and Site 3. These divisions have been maintained within this report.

3.0 Contamination Summary
In general, across all sites, levels of contamination were higher across Site 3 than Sites 1 and 2 and the Norwest Holst 2005 investigation encountered a wider range of contaminants across Site 3 than the 2009 ground investigation. Across Site 3, elevated levels of contaminants appear to be concentrated to the southeast and southwest, corresponding to the areas formerly housing the Tyne Brewery and to the northwest in an area which was adjacent to a former colliery and firebrick manufacturer.

3.1 Contamination Hotspots
Using the chemical testing data provided by Norwest Holst in their 2005 and 2009 ground investigations, statistical analysis identified outliers (hotspots) of hydrocarbon and lead contamination which will require removal and off site disposal / remediation to remove unacceptable risks to human health. In general, the volume of material removed for each hotspot should comprise a circle with a radius of 5m around the hotspot location, with a depth extending down to 0.5m below the depth of the hotspot sample. Validation testing would be required after removal.

3.2 Site-Wide Elevated Contamination Levels
Following the removal of hotspots from the data set, further data analysis identified site-wide elevations across Site 3 of certain banded aromatic hydrocarbons and benzo(a)pyrene, requiring mitigation / remediation measures for the Site to be suitable for residential end uses and to not represent a significant possibility of significant harm to human health in the context of Part IIA of the Environmental Protection Act 1990.

4.0 Remediation / Mitigation Measures Required
The remediation / mitigation options required for Site-wide elevated contaminants depend on the final end uses, and therefore will be determined by the final Science Central Masterplan. Residential end uses are more sensitive than commercial / industrial uses and consequently require greater levels of remediation / mitigation. Specific measures for individual plots of land cannot be recommended until the Masterplan is complete. Undertaking remediation / mitigation prior to this may result in an overly conservative approach and / or abortive work being undertaken.

4.1 Human Health
Risks to human health will be primarily mitigated by (as a minimum):

- The removal of contamination hotspots;
- The provision of physical barriers between future site users and on site soils through;
    - Extensive areas of buildings and hardstanding; and
    - Use of suitable capping layers.
- Validation testing across all Sites, to include hydrocarbon laboratory testing in areas of residential with gardens end use and landscaped areas for residential without gardens end use;
- Using appropriate gas mitigation measures in all buildings (Gas Characteristic Situation 2).

4.2 Controlled Waters (Groundwater)

Site soils are not considered to be adversely impacting groundwaters and as groundwater quality in the local area is considered to be poor, the following measures are deemed to be sufficient for the protection of groundwaters beneath the site and the River Tyne:

- Localised removal of hotspots for off-site dispoal / remediation;
- Provision of hardstanding and buildings across large parts of site to prevent rainwater percolating through Made Ground;
- Isolation of all drainage from all building and hardstanding areas from Made Ground (infiltration drainage is not considered suitable at this site); and
- Provision of suitable thicknesses of clean capping materials in gardens / landscaped areas and use of an underlying geotextile membrane.

4.3 Trees and Shrubs

Elevated levels of phytotoxic contaminants (substances harmful to plants) were identified at several locations across the Tyne Brewery Complex. The contamination risks to trees and shrubs will be primarily mitigated through the removal of contamination hotspots; use of suitable capping layers; and potential provision of tree pits for particularly large, deep-rooted trees.

4.4 Structures

- Slightly elevated levels of ground gases (carbon dioxide) detected mean that gas mitigation measures suitable for Gas Characteristic Situation 2 will be required across the site.
- Consultation with the statutory water supplier should be undertaken regarding the need to install protective potable water supply piping across the sites due to levels of contaminants exceeding recommended guidelines.
- Given the presence of elevated levels of contaminants potentially aggressive to concrete (primarily sulphates), it is recommended that during the design stage, an appropriate concrete class is selected to withstand any potential chemical attack.

5.0 Short Term End Uses

It is recommended that any short-term Site uses are of a commercial / industrial nature only. The remediation / mitigation required for temporary residential accommodation or other similarly sensitive end uses would be prohibitively expensive for a short term use if the final end use of the site is decided to be commercial / industrial in that area. Short term end uses should minimise contact between on site materials and future end users through the use of hardstanding / capping, suitable uses could include car parking and commercial / industrial storage. The removal of localised hotspots should be undertaken prior to any development on the site, either short or long term.

6.0 Consultation

Copies of this Contaminated Land Strategy should be provided to Newcastle City Council and the Environment Agency for their comment and approval. It is considered that the most suitable remediation ‘way forward’ for the site will be chosen after consultation with both parties.

1 Introduction

1.1 Former Tyne Brewery Site and Proposals

Mott MacDonald Ltd has been commissioned by Newcastle City Council to produce a Contaminated Land Strategy for the former Tyne Brewery Site, Gallowgate, Newcastle Upon Tyne. The site has been subject to several ground investigations and associated reporting in recent years. The purpose of this report therefore, is to bring together all available data to produce a Contaminated Land Strategy for the site in support of its future re-development.

Newcastle Science City (a partnership between Newcastle City Council, Newcastle University and regional development agency One North East) purchased the former brewery site in 2005 and propose to use the site to create a Science Quarter in Newcastle upon Tyne city centre, known as 'Science Central'. The Masterplan for Science Central is likely to include new streets, a new city square, landmark buildings and public spaces opening up the new Science Quarter to the rest of the city centre. The plans also include family homes and apartments, student accommodation and leisure and retail facilities. A site location plan is included in Appendix A , Drawing 225057/3012.

The next stage in the process for this site is the development of the masterplan, specific building plans and submission of planning applications, which will develop the vision and principles agreed as part of the Masterplan process, and set out more detailed development proposals for Science Central.

1.2 Scope of Study

The scope of work for this report includes the following:

- A review of all existing baseline data from previous desk studies;
- A review of all ground investigation data relating to ground conditions and contamination across the site including Norwest Holst ground investigation reporting from investigations undertaken from 2005 to 2009;
- Production of a site specific Contaminated Land Strategy to address contamination risks relating to a variety of end uses;
- Identification of potential site specific contamination mitigation options where appropriate;
- Identification of validation testing requirements across the site;
- Production of drawings as appropriate to indicate historic potentially contaminative land uses, contamination assessment criteria exceedences and remediation recommendations.

Due to ongoing changes in guidance on contaminated land regime, the existing ground investigation data has been reviewed against current regulatory requirements. A short section is provided on potential future changes to current contaminated land legislation.

1.3 Works Completed on Site Post Acquisition

The following section summarises the works undertaken on site to date.

1.3.1 Asbestos Removal

(i) Sites 1 and 3

The removal of asbestos-containing materials from the site was undertaken by the Chirmarn Group appointed as a nominated sub-contractor to the project by Newcastle City Council. All works had been identified against a Type 3 asbestos survey procured by Newcastle City Council. The removal was undertaken on a building by building basis with clearance undertaken by MIS Environmental, the independent analyst appointed by Newcastle City Council. All clearance documentation has been retained by Newcastle City Council Asset Management Team.

The asbestos removal resulted in just over 70 tonnes of asbestos containing materials being removed from site for disposal at a licensed landfill.

(ii) Site 2

The removal of all asbestos-containing materials from this sit was undertaken by Pyeroy, appointed as a nominated sub-contractor to the project by Newcastle City Council. All works had been identified against a Type 3 asbestos survey procured by Newcastle City Council. The removal was undertaken on a building by building basis with clearance undertaken by MIS Environmental the independent analyst appointed by Newcastle City Council.

The asbestos removed from site was disposed of at a licensed landfill.

1.3.2 Demolition Works

(i) Sites 1 and 3

To date, demolition of all buildings, structures and associated items of plant on the former Tyne Brewery site has been undertaken, along with the removal of associated flooring, sub floors and foundations and all basement areas except where specified. Retained basement areas were punctured to provide drainage and backfilled with processed materials. All elements were generally removed up to the site boundary with perimeter walls left in situ below ground to provide support to adjoining footpaths and carriageways. Some concrete hardstandings remain.

All hardcore demolition arisings were crushed to specified gradings. Regrading of the existing site profile followed completion of the demolition works and the site was capped with a minimum of 300mm crushed material. Removal of all vegetation was undertaken including trees and self seeded plants and shrubs.

The Tyne Brewery sub-station formerly supplied the brewery site with all operational electrical needs. The sub-station has been retained to provide a suitable reserve supply for the future site redevelopment.

(ii) Site 2

All buildings were demolished to ground level and all foundations removed from site along with concrete oversite. In areas of concrete oversite, the existing subsurface was turned to a minimum depth of 1.8m and no additional substructures were discovered.

The site was re-graded on completion of substructure removal to tie in with adjacent footpaths.

1.3.3 Further Preparatory Works Required on Site

Future works required prior to the implementation of the Masterplan include grouting of the worked coal seams beneath the site and grouting and capping of mine shafts across the site.

Further preparatory works such as utility provision and diversions, earthworks to level the site, installation of retaining walls and highway infrastructure will be necessary.

1.4 Potential Final End Uses

1.4.1 Long Term

The Masterplan for Science Central includes new streets and public spaces along with research institutes, business properties, family homes and apartments, student accommodation and leisure and retail facilities.

1.4.2 Short Term

It is understood that the site, or parts of the site may undergo short term, temporary re-development prior to development of Science Central. The potential short-term site uses are not yet known, but may be of a commercial or light industrial nature.

1.5 Consultation

Consultation has been undertaken with Phil Hartley at Newcastle City Council regarding the development (see Appendix B), who provided historic maps of the area from 1770 and 1827 were provided.

Copies of this Contaminated Land Strategy will need to be provided to Newcastle City Council and the Environment Agency following finalisation of the Masterplan for their comment and approval. It is considered that the most suitable remediation options selected for the site will be chosen after consultation with both parties.

2 Methodology

The processes followed for this Contaminated Land Strategy are outlined in Figure 2.1.

Figure 2.1: Methodology Flowchart

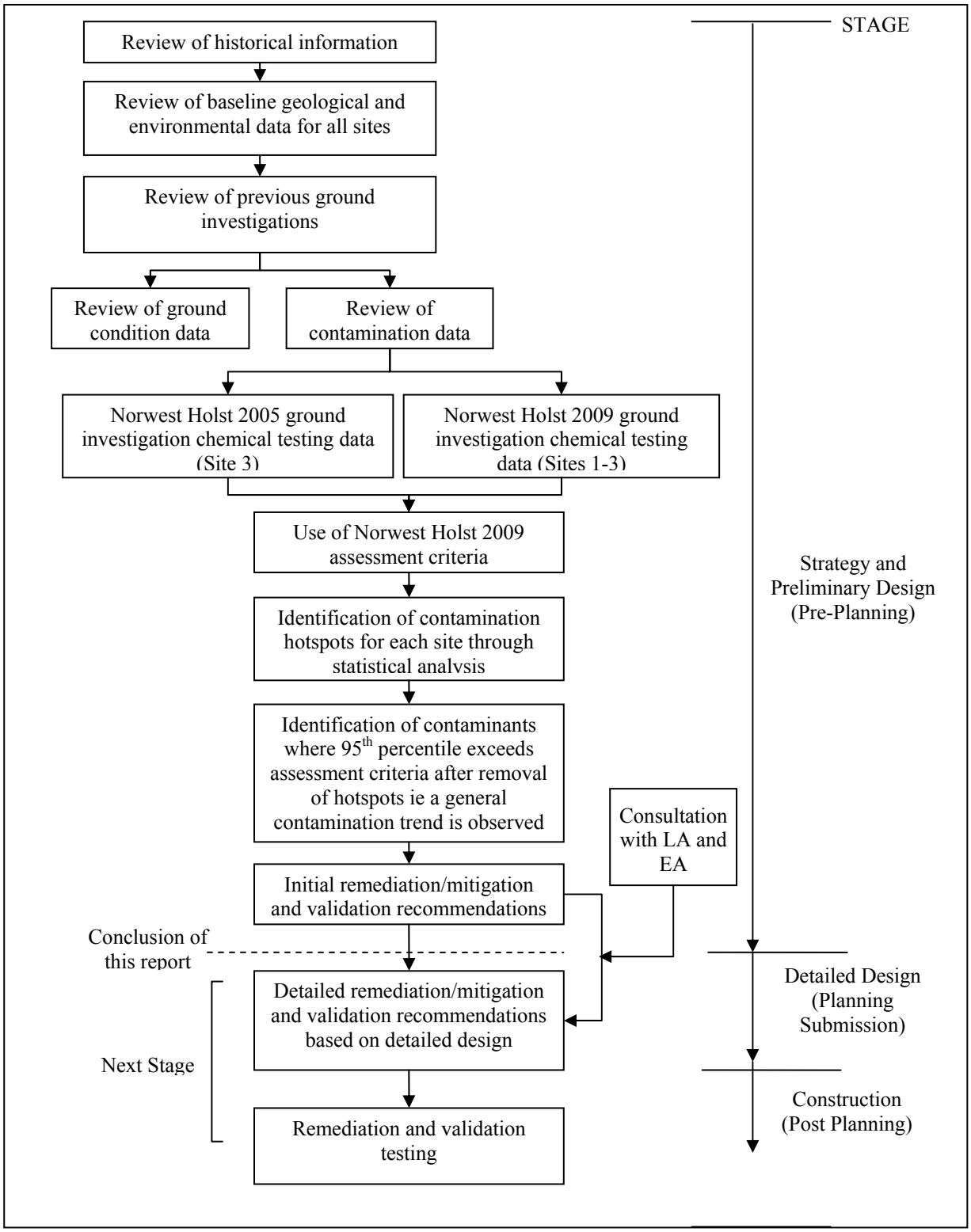

Figure 2.1 shows the methodology followed during the production of this Contaminated Land Strategy in relation to design and statutory processes (planning). The initial remediation / mitigation recommendations provided within this report are sufficient for preliminary design (pre-planning). Following finalisation of the Masterplan, consultation with the Local Authority and Environment Agency would be required in order to finalise specific remediation / mitigation measures required for each section of the site, which will feed into detailed design and support the planning application.

3 Site Baseline Data Review

3.1 Sources of Information

The reports detailed in Table 3.1 below have been used as the primary sources of information for this Contaminated Land Strategy.

Table 3.1: Sources of Information

Date	Author	Document Reference	Title
Nov 1993	Mott MacDonald	25650/01/A	Tyne Brewery Development – Geotechnical Desk Study
Jan 1994	Exploration Associates	A6564/133181	Tyne Brewery Site Development – Factual Report on Ground Investigation
July 1994	Exploration Associates	A6564/134043	Tyne Brewery Site Development – Factual Report on Additional Ground Investigation
Jan 2005	Mott MacDonald	218420/01/A	Tyne Brewery Site Development – Desk Study
July 2005	Mott MacDonald	221442/02/A	Tyne Brewery Site Development – Desk Study No.2
Oct 2005	Norwest Holst	OG/NRD/F14166	Report on a Ground Investigation at Scottish and Newcastle, Newcastle
June 2009	John Hellens (Contracts) Limited	---	Demolition File for Demolition Works to Former Tyne Brewery, Sites 1 and 3, Corporation Street, Newcastle upon Tyne
June 2009	John Hellens (Contracts) Limited	---	Demolition File for Demolition Works to Former Tyne Brewery, Site 2, Corporation Street, Newcastle upon Tyne
June 2009	Mott MacDonald	225057/14/A	Former Tyne Brewery Sites 1, 2 and 3 Ground Risk Register
July 2009	Norwest Holst	F15481A	Report on a Ground Investigation at the Former Tyne Brewery, Newcastle upon Tyne Sites 1 and 2.
July 2009	Norwest Holst	F15481B	Report on a Ground Investigation at the Former Tyne Brewery, Newcastle upon Tyne Site 3.

3.2 Site Divisions

The site is located in the Gallowgate Area to the immediate west of Newcastle City Centre. A location plan is included in Appendix A , Drawing 225057/3012.

The site is divided into three parts for the purposes of investigation – Site 1, Site 2 and Site 3.

- Site 1 has an area of approximately 0.8ha and is located in the southwest corner of the Tyne Brewery complex.
- Site 2 is located to the south of the Tyne Brewery complex and has an area of approximately 1.2ha. It is bounded by an access road and narrow lane to the rear of residential / commercial properties to the south and to the east by St James's Boulevard.
- Site 3 is the former main brewery site with an area of 5.8ha and occupies an approximately triangular area between Corporation Street, Wellington Street and Diana Street. The northern boundary is delineated by Pitt Street.

3.3 Site History

Drawing 225057 / 3003 in Appendix C shows the historic potentially contaminative land uses present across the former Tyne Brewery Complex with respect to the current site layout as ascertained from historical mapping.

3.3.1 Site 1

The earliest large-scale historic map available (1861) shows the site to be occupied by terraced housing. By 1940, the housing had been redeveloped on the corner of Corporation Street / Buckingham Street and on Buckingham Street. In 1982, the site south of Buckingham Street was cleared and it then became used as a car park and tanker storage area, including a workshop building and gatehouse. This layout continued until the demolition and clearance of the site from 2007-2008.

A small electricity sub-station is indicated on the 1950 map to the extreme northwest corner of the site, which also remained present on the 1982 edition. To the immediate north of the site, a penitentiary is located on the east side of Diana Street on the 1861 map, which was replaced by industrial units in the 1940s including a confectionery works, plastic works, garage and warehouse buildings which are still present today.

To the northeast of the site, the former North Elswick colliery is present on the 1940 map with associated shafts. Also in this area a firebrick manufactory and some open reservoirs are indicated on the 1861 plan.

To the east of the site, prior to the expansion of the brewery during the 1970s, a saw mill, timber yard and tobacco factory were present. To the east of the site prior to demolition works was the St Mary's Training and Enterprise Centre, which was formerly a school.

3.3.2 Site 2

From the earliest available map dating 1861, the site was occupied by terrace housing with small industrial premises on the eastern section including cabinet makers, printing works, a flour mill and tyre house.

By 1983, the eastern sector had been cleared and by 1988 a large multi-storey brewery keg / cask depot and warehouse with associated hardstanding to the east and west was built. The narrow, western section of the site was occupied by small commercial buildings including an unspecified works and a garage which were demolished to make way for an open area of hard standing (used as a car park). This layout remained until 2007-2008 when the depot was demolished and the site cleared.

3.3.3 Site 3

From the earliest large –scale historic map available (1861), the centre of the site was open space with several isolated buildings shown. To the north, beyond Buckingham Street, two open reservoirs were present and further north again, a Firebrick Manufacturers was located just to the south of Pitt Street, surrounded by housing.

By the 1919 map, the first indication of the brewery is shown on Corporation Street, adjacent to a saw mill. In the northern section of the site, the reservoirs have now been infilled and extensive areas of housing built in the area. The firebrick works is now labelled as a colliery. Terraced housing and a school have been built on the open land between Corporation Street and Buckingham Street.

On the 1940 map the colliery is shown to be disused and an old shaft is indicated. From this period, industrial and commercial properties on and around the site as well as the brewery have included a tobacco factory, a confectionary works and a garage with terrace housing being demolished to make way for the tobacco factory. The area occupied by the Tyne Brewery was largely unchanged in the decade from 1940 to 1950.

By 1970, the Tyne Brewery had expanded up to Buckingham Street and on Wellington Street. By 1988, the northern section of the site had been cleared with the exception of housing on Buckingham Street, along the south side of Pitt Street and the west side of Wellington Street. Adjacent to the east of Diana Street, the 1970 plan indicated a Plastic Works is present in addition to the Garage and Confectionary Works.

In 1993-1994, the remaining residential properties on the south side of Pitt Street and Wellington Street were demolished including a Public House. Treatment of shallow mine workings was carried out including capping a number of mine shafts. The site was also excavated and re-graded to a shallower profile with a reinforced earth retaining wall along the north, west and part of the southern site boundaries. A new bottling plant was then constructed in the centre of the site. To the south of the plant, St Mary's Primary School was converted into St Mary's Training Enterprise Centre.

This layout remained, until the demolition and clearance of the site in 2007-2008.

3.4 Geology and Mining Baseline

3.4.1 Site 1

According to geological mapping, the underlying geology comprises drift material overlying Boulder Clay, which in turn overlies Carboniferous Middle Coal Measures. Sandstone is present beneath the north-western section of the site and the High Main seam sub-outcrops across the site in a northeast-southwest direction. This is faulted within the northern section of the site.

The Coal Mining Authority Report indicates that the full site area is within the likely zone of influence on the surface from previous workings in four seams of coal at 80m to 230m depth, the last date of working being 1947. The report also indicates that ground movement from these working should now have ceased. In addition, the report indicates that the site is in an area where coal is believed to exist at or close to the surface that may have been worked at some tie in the past. There are no recorded shafts at this site, although there may exist locally mine entries of which the Coal Authority have no knowledge.

3.4.2 Site 2

According to geological mapping, the underlying material comprises drift deposits of Boulder Clay overlying Carboniferous Middle Coal Measures. The Metal seam sub-crops at the far western tip of the site and the Five Quarter (Impoverished) seam runs across the centre of the site in a north-east to south-west direction.

The Coal Mining Authority Report indicates that the full site area is within the likely zone of influence on the surface from previous workings in four seams of coal at 80m to 230m depth, the last date of working being 1947. The report also indicates that ground movement from these working should now have ceased. In addition, the report indicates that the site is in an area where coal is believed to exist at or close to the surface that may have been worked at some tie in the past.

The report indicates the presence of one known mine shaft within the site boundaries located at an approximate grid reference 424230E, 564192N on the former area of hardstanding east of the depot. There are no treatment details available for this shaft. An additional shaft (approximate grid reference 424194E, 564240N) has also bee identified within around 20m of the site on the northern side of Corporation Street, again with no available treatment details. There may also exist locally mine entries of which the Coal Authority has no knowledge.

3.4.3 Site 3

According to geological mapping the underlying geology comprises drift deposits of Boulder Clay overlying Carboniferous Middle Coal Measures in the south and sandstone in the north. The High Main Seam (up to 2.0m thickness) is shown to sub-outcrop across the site in an approximate east-west direction just north of the former Bath Lane Terrace, underlain by the Metal Seam, shown to sub-crop to the south. Both seams are affected by a pair of east-west trending faults with a downthrow to the south. The impoverished Five Quarter Seam sub-outcrops to the south of the site but traverses the extreme south-east corner of Corporation Street. Five known mine shafts are shown to exist within the site boundaries.

These mine entries are also indicated on the Coal Authority Mining Report. Two of these are located on the former Elswick Colliery and are recorded as having been grouted and capped in 1994. Two shafts are recorded on the western side of Wellington Street and one shaft to the north of Corporation Street. However, there may also exist in the locality, mine entries of which the Coal Authority has no knowledge.

3.5 Additional Environmental Information

3.5.1 Hydrogeology

According to the Tyne and Tees (Sheet 5) 1:100,000 Groundwater Vulnerability Map, the site is underlain by a minor aquifer (Carboniferous Coal Measures). These can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although not producing large quantities of water for abstraction, they are important for local supplies and in supplying base flow to rivers.

Groundwater within Coal Measures is known for having poor quality, containing high levels of sulphates and heavy metals, and often having an acidic pH.

The soils across the site are classed as having an assumed 'High Leaching Potential'. This is because soil information for restored mineral workings and urban areas is based on fewer observations than elsewhere. A worst case vulnerability classification if therefore assumed until proven otherwise.

The site is not within, or in close proximity to a Groundwater Source Protection Zone.

3.5.2 Hydrology

The closest water body to the site is the River Tyne, located approximately 1km to the southeast. The River Tyne is tidal at this point.

The site is not located within a designated river flood zone according to Environment Agency flood mapping.

3.5.3 Landfills

The nearest registered landfill site is located over 550m to the west of the site with Newcastle Upon Tyne City Council as the licence holder. It accepted inorganic wastes such as rock and rubble. The licence was surrendered in 1981.

No evidence of landfilling is indicated within the site boundaries from the Landmark Envirocheck report. However, anecdotal evidence from former brewery operatives suggest that man-made materials *may* have been deposited on site or within former mine entries to dispose of materials and to fill voids. Landfilling will also have occurred in the past during construction of brewery buildings to form a level plateau. This is most evident at the south of Site 3 along Corporation Street, the eastern boundary of Site 2 and the north eastern corners of Site 3. There is no evidence to suggest if this was conducted in a controlled or uncontrolled manner.

4 Previous Investigations – Ground Condition Review

There have been several ground investigations undertaken at the Tyne Brewery Site in recent years as listed in Table 4.2 below. They are discussed in more detail in this section and Section 5.

Table 4.2: Ground Investigations at the Tyne Brewery Site

Investigation Details	Site Covered	Date
Exploration Associates Ground Investigation	1 and 3	1993-1994
Norwest Holst Ground Investigation	3	2005
Norwest Holst Gas Monitoring	3	2005-2006
Norwest Holst Supplementary Ground Investigation	1, 2 and 3	2009

4.1 Exploration Associates

Two programmes of ground investigation were undertaken by Exploration Associates during December 1993 and May 1994 on behalf of Scottish and Newcastle Beer Production Limited. The investigation was concentrated on the northern area of the brewery site, north of the old alignment of Buckingham Street.

The initial ground investigation undertaken during December 1993 covered predominantly Site 3 with a few locations located within Site 1 and comprised twenty-six boreholes using a combination of cable percussive and rotary methods, twenty-one trial pits and two trial trenches. The additional ground investigation completed in May 1994 comprised nine boreholes using cable percussive and rotary methods. Site 2 was not covered in this investigation.

- At Site 1, the ground investigation revealed thicknesses of Made Ground to 1m-4.5m bgl overlying Boulder Clay in approximately half of the locations with thicknesses varying from 0.5m-2.6m.

- At Site 3, the ground investigation along with information from BGS boreholes in the area revealed thicknesses of Made Ground from 0.3m-7.7m bgl overlying Boulder Clay in most locations with thicknesses varying from 0.45m-3.0m.

- Underlying the Boulder Clay across both Sites 1 and 3 (directly below Made Ground where the Boulder Clay is absent), the Middle Coal Measures (sandstone, siltstone, mudstone) were encountered with several thin coal seams and voids from past coal workings.

It should be noted that ground levels have significantly reduced since these investigations.

4.2 Norwest Holst Ground Investigation 2005

In September 2005, Norwest Holst Soil Engineering Ltd (NHSEL) was instructed by Newcastle City Council to carry out a ground investigation at the Scottish and Newcastle Brewery, Newcastle.

The investigation was undertaken across Site 3. At the time of investigation, the northern area investigated comprised the bottling plant and warehouse surrounded by a concrete apron with a 4m high retaining wall running along the northern and western boundaries. St Mary's Training and Enterprise Centre was present to the southwest of the bottling plant and a tanker storage bay to the south of the main entrance off Wellington Street.

A total of thirty-seven boreholes and seventy-six window sample holes were formed across the site. See Appendix A for a plan showing the location of all 2005 investigation locations (Drawing 225057/3013). Groundwater and gas monitoring installations were fitted in a representative spread of boreholes across the site. Gas monitoring was undertaken at weekly intervals for four weeks after the completion of site works. A twelve month gas monitoring programme was also undertaken following the completion of site works (see Section 5.2). A programme of contamination testing was scheduled by NHSEL and soil and groundwater samples were sent to ALControl Geochem (Deeside).

4.2.1 Geology Encountered

(i) Made Ground

Made Ground was encountered at all exploratory locations across the site from depths of 0.4m-5.1m bgl. In the northern area it generally comprised a concrete slab overlying 0.2m of hardcore of limestone gravel. Beneath this there was a mix of sand, gravel and cobbles of brick, concrete, cinder, ash, wood and coal. To the south, Made Ground comprised a mix of clay, sand, gravel and occasional cobbles of brick concrete, ash, slag, coal, sandstone and cinder.

The maximum depth of Made Ground was encountered within the old brewery in the southeastern corner of the site. Reinforced concrete was encountered throughout many of the buildings and was found to be at least 1m thick in places with steel reinforcement bars of up to 30mm in diameter. Within the former bottling plant, the structural Made Ground was noted to lie directly on top of natural strata.

(ii) Superficial Deposits

Underlying the Made Ground, superficial deposits comprising firm to stiff slightly gravelly sandy clay were encountered between depths of 0.2m-4.7m bgl. The presence of the Boulder Clay was sporadic across the site with no superficial deposits being encountered in many window sampler holes and boreholes.

(iii) Carboniferous Strata (Middle Coal Measures)

All exploratory holes extended beneath Made Ground and superficial deposits in the north of the site encountered Middle Coal Measures (mudstones, siltstones and sandstones). Various coal seams were encountered beneath the site.

4.2.2 Groundwater and Gas

Groundwater was encountered in all of the rotary follow on boreholes and in one window sampler location (WS105) although all were dry after 20 minutes.

Gas monitoring recorded methane in only one borehole at 25.8%-3838% (BH96). Carbon dioxide levels were recorded typically in the range 3.5%-21% and oxygen levels from 3.5% to 21.0%. Gas flow rates were shown to vary from <0.1 l/hr to 10.2 l/h. A twelve month gas monitoring programme was undertaken following the completion of site works (see Section 5.2).

4.3 Norwest Holst Ground Investigation 2009

In March 2009, Norwest Holst undertook a ground investigation across Sites 1 and 2, along with supplementary ground investigation along predominantly the southern and eastern parts of Site 3.

4.3.1 Locations

(i) Sites 1 and 2

A total of nine boreholes were formed to depths between 0.40m and 6.70m using conventional light cable percussive techniques. Groundwater and gas monitoring installations were fitted in all except two of the boreholes formed.

A total of forty-eight trial pits were dug to depths of between 0.30m and 6.00m. These trial pits were located around the site to provide a reasonable indication of the depth and nature of the Made Ground.

See Appendix A for a plan showing the location of the 2009 investigation locations.

(ii) Site 3

Ten boreholes were formed to depths between 2.1m and 7.4m using conventional light cable percussive techniques. Groundwater and gas monitoring installations were fitted in all except one of the boreholes formed.

Thirty one trial pits were excavated to depths between 2.0m and 4.5m. The trial pits were located around the site to provide a reasonable indication of the depth of the Made Ground.

See Appendix A for a plan showing the location of the 2009 investigation locations.

4.3.2 Geology (All Sites)

(i) Made Ground

Made ground typically between 0.20m and 5.00m (3.80m maximum in Site 1) thick across Sites 1 and 2 and 0.5-4.5m thick across Site 3 was encountered in all of the exploratory holes.

The Made Ground was of two distinct types with an upper compacted Class 6F2 material (sandy gravel comprising fragments of concrete and brick) over older more variable and clay rich materials. The Class 6F2 fill was not found in the extreme northern or western parts of Site 1. The older, deeper Made Ground was typically a gravelly sandy clay with some cobbles and boulders in places. Other materials were also identified including ash, wood, metal and plastic.

In Site 2 several occurrences of old buried concrete or brick structures were also found at depths of up to 3.00m.

(ii) Superficial Deposits

In Site 1, up to 2.8m (more usually 1.00m to 1.50m) of generally medium dense to dense gravelly sands were found beneath the Made Ground overlying the sandstone bedrock from which they appear to have been closely derived. In places however the Made Ground rested directly upon the bedrock and no drift deposits were found.

In Site 2 up to 5.90m of drift deposits were found to a maximum depth of 10.50m, apparently thickest and deepest along the eastern part of the site. The materials beneath Site 2 were generally stiff to very stiff slightly sandy gravelly or slightly gravelly clays (boulder clay) with the gravel being commonly of sandstone mudstone and coal fragments.

Across Site 3 Sandy, gravelly clay deposits were encountered in several of the trial pits and boreholes at depths of between 1.0m and 3.3m. This was seen to be predominantly firm, with gravel of sandstone, mudstone and mixed igneous lithologies.

(iii) Carboniferous Strata

Across Sites 1 and 2, Coal Measures strata were encountered at varying depths in all except one (which terminated in Made Ground) of the boreholes formed on the site. The majority of trial pits formed on Site 1 also encountered solid geology of sandstone at the base of the pits. Sandstone, mudstone, various coal seams and seat earths were all encountered in varying proportions across Site 2. Most boreholes encountered areas of excessively broken ground, possible packed waste or cavities and other indicators that suggest the presence of worked coal seams at relatively shallow depths beneath the site.

Across Site 3 Coal Measures geology was encountered in all except one of the boreholes formed, with sequences showing mudstone, sandstone, coal and siltstone in varying proportions. Areas of excessively broken ground, possible packed waste and other indicators appear to suggest the presence of worked coal seams at relatively shallow depths beneath the site.

5 Previous Investigations - Contaminated Land Data Review

5.1 Norwest Holst 2005 Ground Investigation

The ground investigation undertaken across Site 3 by Norwest Holst in 2005 included chemical testing of soils and groundwaters across the site for contamination assessment purposes. The conclusions of this report are summarised below:

- The chemical testing data showed that the Made Ground encountered across the site, although containing slightly elevated levels of heavy metals at isolated locations and slightly elevated PAH compounds across the site, in the majority of cases, did not contain contaminants at levels which exceeded the assessment criteria.

- Slightly elevated hydrocarbon levels were also encountered in the area of the former bottling plant, the former tanker storage bay and the former southeastern brewery buildings. Speciated testing revealed that hydrocarbon contamination at the site was not present at levels exceeding the risk based screening levels for individual carbon bands.

- Levels of various phytotoxic contaminants present across the site showed that some heavy metals were present at levels which could inhibit / preclude plant growth.

- The results of leachate analysis showed that certain metals and PAH compounds encountered in the Made Ground across the site were mobile - levels of e.g. arsenic, zinc, chromium and copper leached from the Made Ground samples exceeded water quality standards used. Similarly, the results from groundwater analysis showed elevated copper, nickel and zinc and elevated levels of PAHs. However, the sum of the four most important PAHs (as recommended by the Drinking Water Inspectorate) mostly fell below the Drinking Water Quality Standard.

- During the post site works monitoring visit, elevated levels of carbon dioxide between <0.1% and 7.0% were detected with correspondingly reduced oxygen levels as low as 3.5%. Methane was found in BH96 only, at levels varying from 21.4% to 38.8%. Elevated carbon monoxide levels of between 1ppm and 510ppm were also encountered. Gas flow readings of between <0.1 and 10.0 l/h were recorded.

- The spatial distribution of the elevated gas readings suggested that the most elevated readings were encountered in the wells installed within the coal seams. It was noted that the gas flow rates declined with time, indicating that the formation of the boreholes resulted in the release of pockets of gas contained within the coal seams beneath the site which have equilibrated with time.

A contaminated land risk assessment was undertaken by Norwest Holst as part of the report, identifying potential sources, pathways and receptors of contamination and concluded the following (prior to mitigation):

- With regard to human health risks, a potential high long-term risk was identified to residents living in proposed structures who would have access to a garden or landscaped area from arsenic and PAH contamination (this is not considered to pose a short-term risk to construction workers). A further risk to humans is present in the form of ground gas and the elevated levels of carbon dioxide (an asphyxiant) in confined spaces, and methane which is potentially explosive.

- A high risk was also identified to any plants grown on landscaped areas due to elevated levels of phytotoxic heavy metals in Made Ground – deep rooted trees and shrubs are likely to come into contact with these contaminants even with a thin layer of topsoil present.

- The level of risk to surface and groundwaters from contaminants in the Made Ground was deemed to be low, mainly under the assumption that future development would result in widespread hardstanding across the site and improve drainage, thus preventing rainwater from percolating through the Made Ground. There are no groundwater abstractions within 2km of the site and the groundwater vulnerability is classed as intermediate because the water within Coal Measures is generally of poor quality, containing high levels of heavy metals and sulphates which makes it unsuitable as a potable source.

- Risks to structures were judged to be medium because although elevated levels of methane, carbon dioxide and carbon monoxide had been identified, the flow rates were low and concentrations decreased with time as trapped pockets of gas escaped. Gas protection measures were recommended for this site.

- Suggested remediation options by Norwest Holst included the usage of a cover system on any areas of soft landscaping comprising 600mm of clean topsoil and / or subsoil which is the maximum depth to prevent mixing with the contaminated soil. It was recommended that suitable PPE be worn by construction workers.

5.2 Norwest Holst Gas Screening Letter Report

Following the Norwest Holst site investigation carried out in September 2005, it was recommended that gas monitoring was carried out for another 11 months in order to provide sufficient gas monitoring data to characterise the existing gas regime.

The spatial distribution of the elevated gas readings suggested that the most elevated readings were encountered in the wells installed within the coal seams. It was noted that the gas flow rates declined with time, suggesting that the formation of the boreholes resulted in the release of pockets of gas contained within the coal seams.

The monitoring (which was carried out during period of low/falling atmospheric pressure where possible) showed methane levels decreasing from October to a low of <1% LEL in March and no elevated methane was recorded on site for a period of two months suggesting methane production to be localised and associated with a weathered coal later encountered at that location. The methane encountered was at depth (approximately 14m bgl) and was considered to have limited potential to migrate to the surface.

It was therefore suggested that the site be characterised in terms of carbon dioxide, which was encountered across the whole site, rather than in terms of methane from a single borehole.

From the concentrations and flow rates, CIRIA C659 (now C665) guidance was followed to determine gas screening values for the different locations and from this the gas Characteristic Situation for the site. From this analysis, gas protection measures in accordance with Characteristic Situation 2 were recommended across the site, which should incorporate the following:

Residential:

- Reinforced concrete cast in situ floor slab (suspended, non suspended or raft) with at least 1200 g DPM and underfloor venting;
- Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting; and
- All joints and penetrations sealed.

Commercial / Industrial:

- Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM;
- Beam and block or pre cast concrete slab and minimum 2000g DPM / reinforced gas membrane;
- Possibly underfloor venting or pressurisation in combination with the above depending on use; and
- All joints and penetrations sealed

5.3 Norwest Holst 2009 Ground Investigation

5.3.1 Conceptual Model

Norwest Holst identified the primary source of contamination at the site as being the contaminants within on site Made Ground and some shallow Natural Soils. Contaminants present are discussed in Section 6.2.

The following potential contaminant pathways have been identified at the site:

- Dermal contact with soil;
- Inhalation and ingestion of soil related dust both indoor and out door;
- Consumption of home grown vegetables;
- Migration of soluble or otherwise mobile contaminants in groundwater; and
- Migration of ground gases into structures.

Potential receptors have been identified and are listed below:

- Residential with plant uptake human users of the site;
- Residential with out plant uptake human users of the site;
- Controlled waters both on and off site;
- Structures; and
- Human health.

5.3.2 Assessment Criteria

Details of the assessment criteria for soils used by Norwest Holst can be found in Appendix D

5.3.3 Risk Summary for Sites 1 and 2

(i) Risks to Humans

Norwest Holst concluded:

- There is a very low level of risk to current site users from contaminants identified within the Made Ground for Sites 1 and 2 due to the relatively low levels of contamination recorded.

- The level of risk to humans for a residential with plant uptake end use of Site 1 and Site 2 is considered to be low to moderate. While TPH screening assessment criteria were exceeded on both Sites 1 and 2, the level of carcinogenic PAH indicator species was recorded below the human health assessment criteria for the sensitive end use of residential with and with out plant uptake. Recorded levels of TPH aliphatic and aromatic carbon banding for Site 1 and Site 2 suggest that the TPH is associated with the higher and less toxic aromatic carbon banding.

- The level of risk for the end use of commercial and industrial use for Site 1 and Site 2 is considered to be very low due to the low levels of contaminants identified within the Made Ground and the likely addition of 150mm of suitable topsoil in landscaped areas. Additional protection of human health is provided in areas of hard standing and building foot print as these are regarded as providing a suitably protective cover layer.

- Elevated pH concentrations in leachate and groundwater samples are highly unlikely to adversely affect human health for any of the above land use scenarios.

(ii) Risks to Vegetation

The level of risk to vegetation was determined to be low due to relatively low levels of phyto-toxic contaminants being present. Slightly elevated levels of boron were encountered in two trial pits.

(iii) Risks to Controlled Water

Norwest Holst concluded:

- The level of risk to groundwater from the contaminants encountered in the Made Ground on site is considered to be low. The Environment Agency R&D P20 methodology considers contamination of the groundwater from contaminated land as being a function of that contamination. No significant sources of PAH, TPH, phenol or VOC contaminated Made Ground were identified during the investigation.

- Laboratory test data for leachate and groundwater recorded mercury, PAH and TPH below laboratory detection limits but slightly above the conservative water quality assessment criteria with phenol recorded in groundwater only at levels below the drinking water quality standard.

- Inorganic contaminants in leachate exceeding the EQS were recorded as ammonia (free) in Site 2 and elevated pH across both sites. Elevated levels of ammonia identified within the leachate results were not recorded in the groundwater test results.

- Redevelopment of the site will reduce potential leaching of contaminants by reducing infiltration and in addition, the distance from the site to potential off-site receptors is significant. For example, the nearest surface water feature (River Tyne) is located 1km down gradient of the site boundary.

- Groundwater analysis showed the groundwater located within the Made Ground, Boulder Clay and deeper aquifer within the coal measures to contain elevated levels of nickel. Elevated levels of copper and elevated pH were recorded in the groundwater encountered in the Made Ground at one location. Chloride was also recorded as being elevated at two locations. These elevated levels of inorganic contaminants are likely to have originated from the natural sources such as the underlying coal measures which are also present within the Made Ground as gravel.

- It is considered unlikely that Site 1 and Site 2 are contributing to any potential groundwater contamination within the localised area.

5.3.4 Risk Summary for Site 3

(i) Risks to Humans

Norwest Holst concluded:

- It is considered that there is a very low level of risk to the current site users from contaminants identified within the Made Ground for Site 3 due to relatively low levels of contamination recorded in the Made Ground.

- The level of risk to humans for a residential with plant uptake end use of Site 3 is considered to be moderate. The TPH screening assessment criteria were exceeded at depths of 0.10m to 1.0m with the level of carcinogenic PAH indicator species benzo(a)pyrene and dibenzo(a,h)anthracene also recorded above the human health assessment criteria. Recorded levels of TPH aliphatic and aromatic carbon banding for Site 3 at depths of 1.40m to 3.0m suggest that the TPH is associated with the higher and less toxic aromatic carbon banding.

- The level of risk to humans for a residential without plant uptake end use is considered to be low to moderate for Site 3. The TPH screening assessment criteria were exceeded at depths of 0.10m to 1.0m with the level of carcinogenic PAH indicator species benzo(a)pyrene also recorded above the human health assessment criteria.

- The level of risk to humans for the end use of commercial and industrial for Site 3 is considered to be very low due to the low levels of contaminants identified within the Made Ground.

- The risks identified are commonly remediated by the addition of 150mm of suitable topsoil in landscaped areas and hardstanding in areas occupied by car parking and building foot prints.

- Elevated pH concentrations in leachate and groundwater samples are highly unlikely to adversely affect human health for any of the end use scenarios.

(ii) Risks to Vegetation

The level of risk to vegetation has been determined to be low. Slightly elevated levels of zinc were encountered in three trial pits at depths ranging from 0.10m to 1.0m.

(iii) Risks to Controlled Water

Norwest Holst concluded:

- The level of risk to groundwater from the contaminants encountered in the Made Ground on site is considered to be low. The Environment Agency R&D P20 methodology considers contamination of the groundwater from contaminated land as being a function of that contamination. No significant sources of PAH, TPH, phenol or VOC contaminated Made Ground was identified during this investigation.

- Laboratory test data for leachate and groundwater recorded PAH and TPH below laboratory detection limits with phenol recorded in groundwater only at levels below the drinking water quality standard. Leachate test results showed PAH and benzo(a)pyrene not to be leachable from the Made Ground. Further more no potable water abstractions or surface water features were identified within 1km down gradient of the site boundary.

- Inorganic contaminants in leachate exceeding the EQS were recorded as ammonia (free) and elevated pH. Elevated levels of ammonia identified within the leachate results were not recorded in the groundwater test results.

- Any redevelopment of the site will reduce infiltration rates and therefore reduce any risks from leachable contaminants such as ammonia and elevated pH.

- Groundwater analysis showed the groundwater located within the Made Ground and deeper aquifer within the coal measures to contain elevated levels of nickel and chloride above the DWQS and EQS. These elevated levels of inorganic contaminants are likely to have originated from natural sources such as the underlying coal measures which are also present within the Made Ground as gravel. It is considered unlikely that Site 3 is having a significant contribution to any potential groundwater contamination within the localised area.

5.3.5 Gas Monitoring For Sites 1, 2 and 3

Several phases of ground gas monitoring have been carried out on site with the previous ground gas risk assessment carried out by NHSED in August 2007 and presented in letter report F14587/CDW/001. During the 2009 investigation:

- Across Site 1, the gas monitoring which was carried out (where possible) during days of low or falling atmospheric pressure produced Carbon Dioxide readings in the range <0.1% to 0.5% and Oxygen levels were in the range 19.3% to 20.6%. Methane was not recorded at detectable levels during the monitoring visits. Gas flow was recorded between <0.1 and 0.1 litres per hour.

- At Site 2, post site monitoring works recorded levels of carbon dioxide in the range of <0.1% to 2.6%. Oxygen levels were in the range of 10% to 20.5% with no methane being recorded. Gas flow was recorded between <0.1 and 0.1 litres per hour.

- Across Site 3, the levels of carbon dioxide detected were in the range <0.1% to 0.2% and oxygen levels were in the range 19.5% to 20.9%. Gas flow was recorded at <0.1 l/h with no methane recorded above detection limits.

The methodology used to carry out a semi-quantitative estimate of the risks from ground gas at the site is that described in CIRIA Report C665 which recommends following the classification system proposed by Wilson and Card in CIRIA Report 149 which is summarised in Table 9.

The current gas levels and flow rates recorded on Sites 1, 2 and 3 provide gas screening values below the upper limit of 0.07 l/hr for Characteristic Situation 1. However, the limited ground gas data gathered during this phase of assessment is regarded as complimentary to the previous ground gas data and risk assessment carried out by NHSED in August 2007 with the recommendations for use of Characteristic Situation 2 gas prevention measures.

5.3.6 Norwest Holst Recommendations

Across all sites, the following mitigation measures were recommended:

- Ground gas mitigation measures suitable for Characteristic Situation 2 for all buildings;
- A suitable protective cover layer for residential with plant uptake along with 150mm topsoil layer to be introduced as a growing media for all end uses;
- Consultation with the statutory water supplier regarding the need to install protective potable water supply piping across the sites due to levels of TPH and pH in the Made Ground;
- Assessment for the end use of residential with plant uptake could be carried out by the collection of samples of Made Ground from depths of 0.10m to 1.0m and chemical testing of those samples using the UK-TPHCWG testing method. The results from this testing should be subject to a Detailed Quantitative Risk Assessment (DQRA) in order to fully ensure that all Sites are suitable for the end use of residential with plant uptake; and
- A cover layer in areas proposed for use as residential gardens is also likely to be needed. Agreement from the Local Authority Contaminated Land Officer on the suitable depths of cover used on site should be obtained prior to construction of the cover layer. The depth of cover should be suitably protective of human health based on the assumption that cultivation of the garden areas may take place and include double digging of the soils.

6 Contaminated Land Strategy

6.1 Potential Site End Uses and Assessment Criteria

The Masterplan for Science Central is likely to include new streets and public spaces along with research institutes, business properties, family homes and apartments, student accommodation and leisure and retail facilities.

The final end use selected for each development plot of the site will impact the assessment criteria required to appraise contaminant levels within site soils with regard to human health. Therefore, the levels of remediation / mitigation required to make the site suitable for that particular end use will vary across the site.

Contaminated Land Exposure Assessment (CLEA) methodology is a risk assessment model which estimates the long term exposure to contaminants in the soil for humans and predicts the amount of contaminant to which a person might be exposed based on a given soil concentration. Following this methodology, the Environment Agency (EA) has developed generic land use scenarios in order to derive generic Soil Guideline Values (SGVs), which are scientifically based generic assessment criteria, used as a screening tool for the quantitative assessment of land contamination. They represent trigger values (indicators) to show that above the level specified for each particular site end use, soil concentrations may pose a *possibility of significant harm* to human health.

The current Masterplan is not yet in its final form and so the limits relating to three generic end uses which are considered to be applicable to this site have been used for comparison:

- Residential with gardens;
- Residential without gardens; and
- Commercial / Industrial.

To assess the risks to human health in their 2005 and 2009 site risk assessments, Norwest Holst used EA SGVs along with Generic Assessment Criteria Values (GAC) for missing contaminants of concern as derived by the Chartered Institute of Environmental Health (CIEH) in partnership with Land Quality Management (LQM).

Norwest Holst also note that at the time of the 2009 ground investigation reporting, the CLEA methodology is experiencing a period of readjustment with parameters used to model human health exposures changing to better reflect the current human characteristics of weight as well as changes in building design and toxicological and chemical property values. Changes in documentation have also taken place with the withdrawal of Contaminated land Reports (CLR) 7 to 10 and the SGVs with limited revised SGVs being presently available at this time.

The SGVs / GACs used by Norwest Holst for the 2009 soils analysis (along with the criteria used for leachate and groundwater analysis) can be found in Appendix B The 2009 limits used by Norwest Holst have been applied to the data collected during both their 2005 and 2009 ground investigations in this section for consistency.

6.2 Site Soils

6.2.1 Contamination Testing Results

In general, across all sites, levels of contamination were higher across Site 3 than Sites 1 and 2. The Norwest Holst 2005 investigation also encountered a wider range of contaminants across Site 3 than the 2009 ground investigation. Contamination testing results for both the 2005 and 2009 investigations can be found in Appendix E and Drawings 225057/3004-3006 in Appendix F pictorially represent the locations with contaminant levels exceeding SGVs / GAC for soils.

Across Site 3, elevated levels of contaminants appear to be concentrated to the southeast and southwest, corresponding to the areas formerly housing the Tyne Brewery and to the northwest in an area which was adjacent to the former colliery and firebrick manufacturer. The following contaminants were identified in general:

- Southeast – Mixture of heavy metals, TPH and PAH (area of former Tyne Brewery)
- Southwest – TPH and PAH (concentrated around area of former tanks)
- Northwest – Heavy metals and PAHs (adjacent to former colliery and firebrick manufacturer)

Table 6.3, below shows the SGV / GAC exceedences across each site for each potential land use. The vast majority of exceedences were encountered in samples of Made Ground.

Table 6.3: Soil Exceedences Summary

Site	End Use	Organic / Inorganic	Parameter/s*
1	Residential With Gardens	Inorganic	Mercury
		Organic	TPH Aromatic > C12-C16, Benzo-a-pyrene
	Residential Without Gardens	Inorganic	Mercury
		Organic	Benzo(a)pyrene
	Commercial / Industrial	Inorganic / Organic	-
2	Residential With Gardens	Inorganic	-
		Organic	TPH Aromatic > C12-C16
	Residential Without Gardens	Inorganic / Organic	-
	Commercial / Industrial	Inorganic / Organic	-

Site	End Use	Organic / Inorganic	Parameter/s*
3**	Residential With Gardens	Inorganic	Copper, lead, zinc, mercury
		Organic	TPH Aliphatic >C12-C16, TPH Aromatic >C7-C8, TPH Aromatic, TPH Aromatic > C10-C12 >C12-C16, TPH Aromatic >C16-C21, TPH Aromatic > C21-C35, naphthalene, benzo(a)pyrene, dibenzo(ah)anthracene, benzene
	Residential Without Gardens	Inorganic	Lead, mercury
		Organic	TPH Aliphatic >C12-C16, TPH Aromatic > C7-C8, TPH Aro > C21-C35, naphthalene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzene
	Commercial / Industrial	Inorganic	Lead
		Organic	Benzo(a)pyrene

- *It should be noted that for both Residential With Gardens and Residential Without Gardens end use, some samples exceeded screening GAC for TPH >C6-C10, >C10-C21 and >C21-C40 and for Commercial / Industrial end use, some samples exceeded screening GAC for TPH >C6-C10. However these criteria are overly conservative and are used as initial screens only. Additional TPHCWG testing on these materials is likely to indicate that most samples do not fail specific banded TPH limits given that the majority of banded testing during the 2009 investigation did not fail.*
- ***Following demolition, much of the surface material across Site 3 was turned over in the search for foundations. Therefore, localised contaminant levels may have altered since the values recorded during the Norwest Holst 2005 Investigation.*

6.2.2 Hotspots of Contamination

The acceptance / rejection of values which exceed SGVs / GACs is not a straightforward process as there is a need to balance the primary goal of health protection with the recognition that contaminants in soil often have high sampling and analytical variability. In determining whether extra sampling / analysis is required, it is useful to know whether a maximum value in a set of measurements is likely to have come from the same population, or whether it is a statistical outlier.

Using the raw chemical testing data provided by Norwest Holst in their 2005 and 2009 ground investigations (and using their SGVs / GAC for continuity, see Appendix B), statistical analysis has been undertaken to identify outliers (hotspots) of contamination, not belonging to the underlying population using the methodology outlined in R&D Publication CLR 7 – Maximum Value Test.

The outcome of this analysis is shown in Table 6.4, where the exceedences of SGVs / GACs were analysed, and hotspots of contamination requiring removal and off-site disposal / remediation are highlighted in orange for each potential end use. Less off-site disposal is required for Commercial / Industrial end use than for the Residential end uses.

Table 6.4: Hotspots of Contamination Identified

		Hotspots To be Removed in order to Pass Outlier Test for Residential With Gardens End Use			Hotspots To be Removed in order to Pass Outlier Test for Residential Without Gardens End Use			Hotspots To be Removed in order to Pass Outlier Test for Commercial / Industrial End Use		
Site	**Parameter**	**Location**	**Depth (m)**	**Value (mg/kg)**	**Location**	**Depth (m)**	**Value (mg/kg)**	**Location**	**Depth (m)**	**Value (mg/kg)**
1	Mercury	-	-	-	-	-	-	-	-	-
1	TPH aromatic >C12-C16*	TP135	2.6	3.80	-	-	-	-	-	-
1	Benzo[a]pyrene	TP129	0.3	1.9	TP129	0.3	1.9	-	-	-
2	TPH aromatic >C12-C16*	TP221	1.5	4.6	TP221	1.5	4.6	-	-	-
		TP224	0.5	2.2	TP224	0.5	2.2	-	-	-
3	TPH aliphatic >C12-C16	-	-	-	-	-	-	-	-	-
3	TPH aromatic >C7-C8	-	-	-	-	-	-	-	-	-
3	TPH aromatic >C10-C12	TP339	1.7	3.50	-	-	-	-	-	-
3	TPH aromatic >C12-C16	-	-	-	-	-	-	-	-	-
3	TPH aromatic >C16-C21	BH16B	1	187.00	-	-	-	-	-	-
3	TPH aromatic >C21-C35	BH16B	1	1205.00	BH16B	1	1205.00	BH16B	1	1205.00
3	Naphthalene	-	-	-	-	-	-	-	-	-
3	Benzo[a]pyrene	BH16B	1	92.50	BH16B	1	92.50	BH16B	1	92.50
		TP339	1.7	48.00	TP339	1.7	48.00	TP339	1.7	48.00
		WS15A	1	29.50	WS15A	1	29.50	WS15A	1	29.50
3	Dibenzo[a,h]anthracene	WS15A	1	13.80	WS15A	1	13.80	-	-	-
		BH16B	1	13.20	BH16B	1	13.20	-	-	-
		TP339	1.7	5.10	TP339	1.7	5.10	-	-	-
3	Benzene	-	-	-	-	-	-	-	-	-
3	Copper	-	-	-	-	-	-	-	-	-
3	Mercury	-	-	-	-	-	-	-	-	-
3	Lead	WS41	0.45	2836.00	WS41	0.45	2836.00	WS41	0.45	2836.00
3	Zinc	-	-	-	-	-	-	-	-	-

As it can be seen from Table 6.4, some testing locations require removal from site and off-site disposal or remediation. Unsuitable soils could be taken to an off-site soil treatment facility, however limited remediation options are available for heavy metal and long-chain hydrocarbon contaminated soils. Some soils require removal for elevated levels of more than one contaminant, which also makes remediation more complex.

In general, the volume of material removed for each hotspot should comprise a circle with a radius of 5m around the hotspot location, with a depth extending down to 0.5m below the depth of the hotspot sample. Validation testing would be required after removal.

Hotspots of contamination requiring removal are pictorially represented on Drawings 225057/3009-3011 in Appendix G

6.2.3 Generally Elevated Levels of Contamination

The Mean Value Test is used to show with a given level of confidence (95th Percentile or US95) that the population mean is less than the assessment criteria.

Following the identification of hotspots requiring removal and off-site disposal / remediation, the Mean Value Test was undertaken on all data both prior to and following the removal of the statistical outliers from the data set.

If the mean value test is passed for a particular contaminant, the site is considered not to present a significant possibility of significant harm to human health in the context of Part IIA of the Environmental Protection Act 1990. However, if the test is failed, then either more samples may be required, or suitable mitigation / remediation measures may be necessary to present the possibility of significant harm to human health from occurring.

Table 6.5 below, shows the results of the Mean Value test for the parameters with exceedences across all sites and for all end uses (highlighted in orange). From the table it can be seen that the following contaminants have a US95 population mean greater than the SGVs / GACs on removal of all identified outliers:

- Residential With Plant Uptake (Site 3)
    - TPH aromatic >C7-C8
    - TPH aromatic >C12-C16
    - Benzo[a]pyrene
- Residential Without Plant Uptake (Site 3)
    - TPH aromatic >C7-C8
    - Benzo[a]pyrene
- CommercialIndustrial
    - No failures

Sites 1 and 2 do not show any failures of the Mean Value Test.

The above means that for residential with and without plant uptake end-uses there is a site wide elevation across Site 3 of certain TPH aromatics and benzo(a)pyrene, which will require specific mitigation / remediation measures for the site to be suitable for these end uses.

Table 6.5: Generally Elevated Levels of Contamination Identified

		Residential With Gardens End Use			Residential Without Gardens End Use			Commercial / Industrial End Use		
Site	Parameter	Residential with gardens end use limits for parameters with exceedences	US95 Test prior to removal of outliers	US95 Test after removal of outliers	Residential without gardens end use limits for parameters with exceedences	US95 Test prior to removal of outliers	US95 Test after removal of outliers	Commercial / industrial end use limits for parameters with exceedences	US95 Test prior to removal of outliers	US95 Test after removal of outliers
1	Mercury	1	pass	na	-	-	-	-	-	-
1	TPH aromatic >C12-C16	2.19	*	-	-	-	-	-	-	-
1	Benzo[a]pyrene	1.12	pass	na	-	-	-	29.7	pass	na
2	TPH aromatic >C12-C16	2.19	*	-	-	-	-	-	-	-
3	TPH aliphatic >C12-C16	40.7	pass	na	42.1	pass	na	-	-	-
3	TPH aromatic >C7-C8	0.624	fail	no outliers	0.694	fail	no outliers	-	-	-
3	TPH aromatic >C10-C12	1.94	pass	na	-	-	-	-	-	-
3	TPH aromatic >C12-C16	2.19	fail	no outliers	-	-	-	-	-	-
3	TPH aromatic >C16-C21	115	pass	na	-	-	-	-	-	-
3	TPH aromatic >C21-C35	157	fail	pass	417	pass	na	-	-	-
3	Naphthalene	3.47	pass	na	6.94	pass	na	-	-	-
3	Benzo[a]pyrene	1.12	fail	fail	1.3	fail	fail	-	-	-
3	Dibenzo[a,h]anthracene	1.12	pass	na	1.3	pass	na	-	-	-
3	Benzene	330	pass	na	330	pass	na	-	-	-
3	Copper	111	fail	pass	-	-	-	-	-	-
3	Mercury	1	pass	na	1	pass	na	-	-	-
3	Lead	450	pass	na	450	pass	na	750	pass	na
3	Zinc	330	pass	na	-	-	-	-	-	-

6.2.4 Remediation / Mitigation Options

The remediation / mitigation options required for each Site will very much depend on the final end use selected and therefore will be determined by the final Masterplan for the overall development. Other than site wide measures to be applied across Sites 1, 2 and 3, specific measures for individual plots of land cannot be recommended until the Masterplan is in its final version. Undertaking remediation / mitigation prior to this may result in an overly conservative approach and / or abortive work being undertaken.

The following Table 6.6 summarises remediation / mitigation recommendations for each site and each potential end use. Table 6.6 must be used in conjunction with the other tables referenced; it is not to be used alone. More specific mitigation measures recommended for the residential with gardens end use are detailed in Table 6.7.

Please note, the following recommendations are all pending discussion with and approval from Newcastle City Council Contaminated Land Officer and the Environment Agency which will be required following finalisation of the Masterplan.

To summarise, risks to human health will be primarily mitigated by:

- The removal of contamination hotspots;
- The provision of physical barriers between future site users and on site soils through;
    - Extensive areas of buildings and hardstanding; and
    - Use of suitable soil capping layers.
- Validation testing across all Sites, to include hydrocarbon laboratory testing in areas of residential with gardens end use and landscaped areas for residential without gardens end use;
- Using appropriate gas mitigation measures in all buildings (Gas Characteristic Situation 2).

As suggested in Table 6.6, it is likely that remediation / mitigation options will need to be undertaken in combination i.e. there is no all-encompassing solution, other than bulk removal of all waste from the site for certain end uses (an expensive, low sustainability option).

Remediation / Mitigation options are pictorially represented on Drawings 225057/3009-3011 in Appendix G

Table 6.6: Remediation / Mitigation Recommendations for each End Use

Site End Use	Site 1	Site 2	Site 3
Residential With Gardens	Unsuitable for end use without specific mitigation measures. See Table 6.7.	Unsuitable for end use without specific mitigation measures. See Table 6.7.	Unsuitable for end use without specific mitigation measures. See Table 6.7.
	Localised removal of hotspots for 'Residential With Plant Uptake End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Residential With Plant Uptake End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Residential With Plant Uptake End Use' detailed in Table 6.4.
	Validation testing required across Site 1 to include banded hydrocarbon testing in areas of residential with gardens. See Validation Table 6.8.	Validation testing required across Site 2 to include banded hydrocarbon testing in areas of residential with gardens. See Validation Table 6.8.	Validation testing required across Site 3 to include banded hydrocarbon testing in areas of residential with gardens. See Validation Table 6.8.
	Garden areas would require specific measures as detailed in Table 6.7 with a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.	**Garden areas** would require specific measures as detailed in Table 6.7 with a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.	**Garden areas** would require specific measures as detailed in Table 6.7 with a minimum of **750mm** imported clean subsoil and **150mm** imported clean topsoil.
	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.
Residential Without Gardens	Localised removal of hotspots for 'Residential Without Plant Uptake End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Residential Without Plant Uptake End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Residential Without Plant Uptake End Use' detailed in Table 6.4.
	Validation testing required across Site 1 to include banded hydrocarbon testing in areas of landscaping. See Validation Table 6.8.	Validation testing required across Site 2 to include banded hydrocarbon testing in areas of landscaping. See Validation Table 6.8.	Validation testing required across Site 3 to include banded hydrocarbon testing in areas of landscaping. See Validation Table 6.8.
	Landscaped areas would require a geotextile membrane and a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.	**Landscaped areas** would require a geotextile membrane and a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.	**Landscaped areas** would require a geotextile membrane and a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.
	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.

Site End Use	Site 1	Site 2	Site 3
Commercial Industrial	Localised removal of hotspots for 'Commercial / Industrial End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Commercial / Industrial End Use' detailed in Table 6.4.	Localised removal of hotspots for 'Commercial / Industrial End Use' detailed in Table 6.4.
	Validation testing required across Site 1. See Validation Table 6.8.	Validation testing required across Site 2. See Validation Table 6.8.	Validation testing required across Site 3. See Validation Table 6.8.
	Landscaped areas would require a geotextile membrane and a minimum of **450m**m imported clean subsoil and **150mm** imported clean topsoil.	**Landscaped areas** would require a geotextile membrane and a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.	**Landscaped areas** would require a geotextile membrane and a minimum of **450mm** imported clean subsoil and **150mm** imported clean topsoil.
	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.	Gas mitigation measures suitable for Characteristic Situation 2 required.

Table 6.7: Residential With Gardens Specific Mitigation Options

Mitigation Option	Advantages	Disadvantages	Statutory Approval Considerations
1 Bulk Removal of Materials from 'Residential With Garden End Use' areas	• Removed environmental liabilities. • Addresses risk to human health and environmental concerns. • Technologically simple.	• Expensive. • Low sustainability (transport, landfill). • Requires significant quantities of imported materials.	• Likely to gain approval from a contaminated land perspective.
2 Provision of impermeable physical barrier beneath 'Residential With Garden End Use' areas	• Risk averse • Does not require significant quantities of imported materials. • Addresses risk to human health and	• Drainage in gardens and landscaped areas may be problematic • Increased construction costs.	• Would require consultation with LA and EA.

Mitigation Option	Advantages	Disadvantages	Statutory Approval Considerations
	environmental concerns	• May impact design.	
3 Provision of permeable physical barrier beneath 'Residential With Garden End Use' areas with suitable capping layer	• Lowest cost option (depending on any excavation required). • Should not cause drainage problems across landscaped areas.	• Capping layer would need to be of significant thickness – may impact site levels. • Excavation of materials in garden areas may be required to ensure correct capping thickness achieved. • Required importation of suitable capping materials.	• Would require detailed consultation with LA and EA for this option and specifically, approval of the capping layer depth, permeable barrier used etc.

6.2.5 Validation Requirements

Following removal of hotspots and prior to the re-development of the Tyne Brewery Sites, validation testing will be required to confirm the removal of identified contaminants and to narrow the testing grid further thus reducing the risks of encountering currently unidentified contamination.

Table 6.8 below shows recommended validation testing to be undertaken at all Sites for each potential end use.

Please note, the following recommendations are all pending discussion with and approval from Newcastle City Council Contaminated Land Officer and the Environment Agency.

Table 6.8: Validation Testing Recommendations

Site End Use	All Sites
Residential With Gardens	• Every proposed garden should have a minimum of one banded TPH and speciated PAH test located on the proposed plot. • Garden areas in general should have laboratory screening samples taken using a 25m^2 grid. • Areas of residential buildings, roads and hardstanding require laboratory screening samples to be taken using a 250m^2 grid.
Residential Without Gardens	• Landscaped areas should have laboratory screening samples taken using a 50m^2 grid (suite to include hydrocarbon testing). • Areas of residential buildings, roads and hardstanding require laboratory screening samples to be taken using a 250m^2 grid.
Commercial Industrial	• Landscaped areas should have laboratory screening samples taken using a 50m^2 grid. • Areas of commercial / industrial buildings, roads and hardstanding require laboratory screening samples to be taken using a 250m^2 grid.

6.3 Controlled Waters (Leachates and Groundwaters)

6.3.1 Contamination Testing Results

Drawings 225057/3007-3008 in Appendix F pictorially represent the locations with contaminant levels exceeding assessment criteria for leachates and groundwaters.

(i) Leachate Results 2009 Investigation – Sites 1, 2 and 3

Across Sites 1, 2 and 3 during the 2009 ground investigation, no leachate samples tested exceeded assessment criteria (a combination of Estuarine Environmental Quality Standards (EQS) and UK Drinking Water Standards (DWS) where no EQS is available (see Appendix B for limits used) with the exception of elevated pH values across the site and some elevated levels of ammoniacal nitrogen. Almost half of all samples had a pH greater than pH 9, with the highest being pH 11.9 at TP221. Seven out of the twenty-five samples sent for leachate testing across all the sites contained levels of ammoniacal nitrogen (as NH_3) exceeding the limit of 0.021mg/l with values of 0.0213-0.0672mg/l.

The detection limits for mercury, benzo(a)pyrene and PAH (Sum 4) slightly exceeded the assessment criteria, however no samples exceeded detection limits and it is not considered that they would pose a significant problem at this site.

(ii) Leachate Results 2005 Investigation – Site 3 Only

The 2005 investigation across Site 3 however, encountered levels of contamination in leachates exceeding assessment criteria (although most exceedences were marginal) summarised as follows (eighteen samples were tested in total):

Table 6.9: Leachate Results 2005 Investigation – Site 3

Parameter	Limit	Number of Exceedences	Exceedance Values
pH	9	3	10.4 (max)
Arsenic	25µg/l	1	27µg/l
Chromium	15µg/l	5	20-66µg/l
Copper	5µg/l	12	7-22µg/l
Lead	25µg/l	2	32-33µg/l
Nickel	30µg/l	1	60µg/l
Zinc	40µg/l	8	42-68µg/l
Napthalene	10µg/l	1	21.6µg/l

Parameter	Limit	Number of Exceedences	Exceedance Values
Benzo(a)pyrene	0.01µg/l	2	0.057-0.485 µg/l
PAH (Sum 4)	0.1µg/l	2	0.16-1.60µg/l

(iii) Groundwater Results 2009 Investigation – Sites 1, 2 and 3

Groundwater samples were taken from seven boreholes during the 2009 investigation.

The detection limits for mercury, benzo(a)pyrene and PAH (Sum 4) slightly exceeded the assessment criteria, however no samples exceeded detection limits and it is not considered that they would pose a problem at this site.

The exceedences are summarised in Table 6.10 below:

Table 6.10: 2009 Groundwater Exceedences

Parameter	Limit	Exceedance	Location
pH	9µg/l	12.2µg/l	BH203
Chloride	250mg/l	260-630mg/l	Four locations
Sulphate	250mg/l	400/530mg/l	BH204/BH202
Ammonical Nitrogen (as NH3)	0.021mg/l	2.4mg/l	BH203
Copper	5µg/l	13µg/l	BH203
Nickel	30µg/l	34-86µg/l	Four locations
Phenols	0.03mg/l	0.14mg/l	BH203

(iv) Groundwater Results 2005 Investigation – Site 3 Only

Groundwater samples were taken from ten boreholes during the 2005 investigation. The results are summarised in Table 6.11 below:

Table 6.11: 2005 Groundwater Exceedences

Parameter	Limit	Exceedance	Location
pH	9µg/l	9.61µg/l	WS105
Sulphate	250mg/l	290-650mg/l	Seven locations

Parameter	Limit	Exceedance	Location
Copper	5µg/l	9-14µg/l	Eight locations
Nickel	30µg/l	40-105µg/l	Three locations
TPH	10µg/l	13/17µg/l	BH39/BH58
Napthalene	10µg/l	10.2µg/l	BH48A
Benzo(a)pyrene	0.01µg/l	0.098µg/l	BH48A
PAH (Sum 4)	0.1µg/l	0.115µg/l	BH48A

6.3.2 Contamination Summary

From the above contamination summaries it can be seen that as for soils, the majority of leachate and groundwater assessment criteria exceedences occur across Site 3.

It should be noted that there is a marked difference in the leachate testing data from the 2009 investigation and the 2005 investigations across Site 3. In 2009, the only contaminants identified in soil leachates are elevated pH and ammoniacal nitrogen (as NH_3). No values exceeded detection criteria for mercury, benzo(a)pyrene and PAH although the detection limits did slightly exceed assessment criteria.

However, in 2005, a greater range of contaminants were identified in leachates including isolated elevated levels of arsenic, lead, nickel, napthalee, benzo(a)pyrene and PAH along with more commonly elevated levels of chromium, nickel and copper. The vast majority of leachate exceedences were only slightly elevated and are not considered to pose a significant risk to groundwaters.

Groundwater testing revealed an absence of contaminants within Site 1 with the exception of chloride, and isolated slightly elevated levels of sulphate, chloride, pH, ammoniacal nitrogen (as NH_3) and copper above assessment criteria across Site 2. Site 3 also had slight exceedences of sulphate and chloride assessment criteria with isolated exceedences of pH, TPH, naphthalene, PAH and benzo-a-pyrene along with more common exceedences of copper and nickel.

Site-wide elevated nickel concentrations in groundwaters were not identified in leachate data, and likewise, elevated levels of zinc in Site 3 leachate testing results were not reciprocated in the groundwater data. The only contaminant exceeding assessment criteria for both leachates and groundwaters on a site-wide scale across Site 3 was copper.

Therefore, it is considered unlikely that site soils in general are contributing to any potential groundwater contamination within the localised area, with the exception of some marginally elevated levels of copper, potentially caused by the percolation of rainwaters through Made Ground exposed on site. Provision of hardstanding and buildings across large parts of site, will help to prevent rainwater infiltration through Made Ground and resultant leachates from reaching groundwaters.

In addition, it should be noted that contaminants identified within groundwaters are largely consistent with the water quality expected of Coal Measures strata – known to be of poor quality (non-potable) with elevated levels of heavy metals and sulphates.

The nearest receptor for groundwater is considered to be the River Tyne, located a considerable distance from the site - approximately 1km to the south. The site is not considered to pose a risk to the River Tyne due to the relatively low levels of contaminants identified, the distance to the river and the generally poor quality of groundwater within Coal Measures beneath the site.

6.3.3 Remediation / Mitigation Required

Given that site soils are not considered to be adversely impacting groundwater and groundwater quality in the local area is considered to be poor, the following mitigation measures are deemed to be sufficient for the protection of groundwater's beneath the site and the River Tyne:

- Localised removal of hotspots as identified in Table 6.4 for off-site disposal / remediation;
- Provision of hardstanding and buildings across large parts of site;
- Isolation of all building and hardstanding area drainage from Made Ground (infiltration drainage is not considered suitable at this site); and
- Provision of suitable thicknesses of clean capping materials in gardens / landscaped areas and use of an underlying geotextile membrane.

6.4 Trees and Shrubs

6.4.1 Risks

Elevated levels of phytotoxic contaminants (substances harmful to plants) were identified across the Tyne Brewery Sites, including the following exceeding ICRCL Phytotoxic Trigger Concentrations:

- Boron (water soluble) - 4 out of 144 soil samples failed the limit of 3mg/kg with values of up to 6mg/kg;
- Copper - 9 out of 145 soil samples failed the limit of 130mg/kg with values of up to 1013mg/kg;
- Nickel - 1 out of 145 soil samples failed the limit of 70mg/kg with values of up to 79mg/kg; and
- Zinc - 45 out of 145 soil samples failed the limit of 300mg/kg with values of up to 1315mg/kg.

6.4.2 Remediation / Mitigation Required

The contamination risks to trees and shrubs should be primarily mitigated through:

- Removal of contamination hotspots;
- Use of suitable capping layers comprising 750mm imported clean subsoil and 150mm imported clean topsoil in residential gardens, and 450mm topsoil and 150mm subsoil in all other landscaped areas. The capping should be underlain by a geotextile membrane to prevent tree and shrub roots coming into contact with potentially contaminated materials; and
- Potential provision of tree pits for particularly large, deep-rooted trees in areas with elevated levels of phytotoxic contaminants.

6.5 Structures

6.5.1 Ground Gas

(i) Risks

From the concentrations and flow rates, the methodology outlined in CIRIA C665 was followed to determine gas screening values for the different locations and from this the Characteristic Situation for the site. From this analysis, the site was assigned as Characteristic Situation 2 and appropriate gas mitigation measures recommended.

(ii) Remediation / Mitigation required

Ground gas mitigation measures across the site will need to include:

Residential With and Without Gardens End Use:

- Reinforced concrete cast in situ floor slab (suspended, nonsuspended or raft) with at least 1200 g DPM and underfloor venting;
- Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting; and;
- All joints and penetrations sealed.

Commercial / Industrial End Use:

- Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 g DPM;
- Beam and block or pre cast concrete slab and minimum 2000g DPM / reinforced gas membrane;
- Possibly underfloor venting or pressurisation in combination with the above depending on use; and;
- All joints and penetrations sealed.

6.5.2 Water Supply Pipes

(i) Risks

Permeation and accelerated deterioration of water supply pipe material can occur due to chemical reactions occurring between the pipe and contaminants in the ground within which it is laid. This can lead to premature failures' resulting in leakage and loss of water quality. The Water Regulations Advisory Service (WRAS) released a guidance note (No 9-04-03) in October 2002, containing a list of threshold values for various contaminants. Where soil values exceed these thresholds, it is recommended that special consideration of material selection will be required for water supply pipes.

Levels of sulphate, pH, arsenic, chromium, lead, mercury, TPH and PAH across the Tyne Brewery complex exceed the limits provided in the WRAS guidance.

It should be noted however, that WRAS detail the thresholds in guidance note No 9-04-03 to be '*far from comprehensive*' and that '*soil sampling may not be the most appropriate method for establishing concentrations'*.

(ii) Remediation / Mitigation required

Consultation with the statutory water supplier should be undertaken regarding the need to install protective potable water supply piping across the sites due to levels of contaminants exceeding the guidelines set out in WRAS guidance note No 9-04-03.

Suitable pipe materials will need to be selected for the levels of contamination present. Materials can include metallic pipes including ductile iron and copper and polythene / aluminium / polythene (PE/AL/PE) compounds depending on the exact chemical composition of the ground.

6.5.3 Buried Structures (Concrete)

(i) Risks

According to BRE Special Digest 1 (Concrete in Aggressive Ground), in the UK, sulphates in soil and groundwater are the chemical agents most likely to attack concrete. The effects can be serious resulting in expansion and softening of the concrete. Sulphate levels in soils, leachates and groundwaters across the site were found to be elevated (up to 9211mg/kg in soils, 96mg/l in leachates and 650mg/l in groundwaters). The fact that the levels are higher in groundwaters than leachates suggests that sulphate is naturally elevated and is likely to relate to high levels within underlying Carboniferous Coal Measures.

Another common cause of concrete deterioration is groundwater acidity and this is sometimes linked with the presence of sulphates, however, pH levels across the Tyne Brewery Complex were found to be alkaline rather than acidic.

Magnesium can be present in natural ground as magnesium sulphate (MgSO4). This is highly soluble and provides as many magnesium ions in solution as it does sulphate ions. In addition, ammonium sulphate, $(NH_4)_2SO_4$, is one of the most aggressive salts to concrete. Elevated levels of ammoniacal nitrogen have been identified in leachates and groundwaters across the Tyne Brewery Complex.

Elevated levels of chloride have been encountered across the site although only in abnormally high concentrations does chloride chemically affect hardened un-reinforced concrete.

(ii) Remediation / Mitigation required

Given the elevated levels of contaminants potentially aggressive to concrete present, it is recommended that at the design stage, the methodology detailed in BRE Special Digest 1 is followed in order to determine the appropriate concrete class required to withstand any potential chemical attack across the Tyne Brewery Sites.

6.6 Short Term End Uses

It is understood that the site, or parts of the site may undergo short term, temporary re-development prior to final end use development of Science Central.

From the information provided in this report it is recommended that any short-term land uses are of a commercial / industrial nature only. The remediation required for temporary residential accommodation or other similarly sensitive end uses would be prohibitively expensive for a short term use if the final end use of the site is decided to be commercial / industrial in that area. Undertaking remediation / mitigation prior to the completion of the final Masterplan (and therefore without the knowledge of which sections of the site have been designated for which end uses) may result in abortive work being undertaken.

The removal of localised hotspots as detailed in Table 6.4 should be undertaken prior to any development on the site either short or long term.

Short term end uses should minimise any contact between on site materials and future end users through the use of hardstanding or a suitable capping medium across the area to be developed. Suitable short term end uses could include:

- Car parking
- Commercial / Industrial storage

Any proposals should be approved by both the Contaminated Land Office at the Local Authority and the Environment Agency prior to temporary re-development.

6.7 Waste Issues

6.7.1 Pre-treatment of Waste

As of October 2007, new regulations came into force as part of the European Landfill Directive (Landfill (England and Wales) Regulations 2002), meaning non-hazardous waste must be treated before it can be sent to landfill in England and Wales.

Waste will have been considered as having undergone pre-treatment if it has undergone a physical, thermal, chemical or biological process (including sorting), which changes the characteristics of the waste, in order to:

- reduce its volume or hazardous nature;
- facilitate its handling; or
- enhance its recovery.

From April 2008 it will be necessary for landfill operators to obtain written evidence from waste producers that their waste has been treated. The EA will be able to monitor compliance with the rules under its inspection programme and audit of landfills and where necessary, take enforcement action.

As best practice, every effort should be made to avoid disposal of material to landfill.

6.7.2 Waste Acceptance Criteria Testing

The Waste Acceptance Criteria test results for Made Ground samples collected from borehole BH201, BH204, BH304 and BH306 have characterised the Made Ground as stable non hazardous waste. Any soils requiring disposal off site disposal should be disposed of to a suitably licensed non hazardous landfill. Further WAC testing for inert wastes may reduce the waste classification from non-hazardous to inert, although many inert landfills will only accept greenfield materials.

If any material is to be removed from site for off-site disposal, the following prices provide an approximate guideline of costs for off site disposal at the time of report writing.

- Non-hazardous waste ~ £55/tonne, plus £40/tonne tax
- Hazardous waste (varies depending on the exact nature of the waste) ~ £60-£150/tonne, plus £40/tonne tax

The alternative to off-site disposal is the re-use of materials on and off the site designated as suitable for the final end use or, for contaminated soils, an off-site soil treatment hub is another option.

6.8 Changes to Current Contaminated Land Legislation

At the time of writing this report the CLEA methodology is experiencing a period of readjustment. Changes in documentation have occurred with the withdrawal of Contaminated land Reports (CLR) 7 to 10 and the SGVs. In summary:

- CLR 9 has been updated by the Environment Agency Human Health toxicological assessment of contaminants in soil Science Report SC050021/SR2; and

- CLR10 has been updated by Environment Agency Updated technical background to the CLEA Model Scientific Report SC050021/SR3.

The Environment Agency intends to periodically release new toxicological reports and Soil Guidance Values (SGV) to replace the withdrawn SGVs with limited revised SGVs being presently available at this time.

Soil assessment criteria in this report have been provided by Norwest Holst who utilised the withdrawn SGVs and Chartered Institute of Environmental Health (CIEH) / Land Quality Management Ltd (LQM) Generic Assessment Criteria (GACs) derived using the CLR9-CLR10 technical documents and CLEA UK in the absence of many new SGVs and toxicological reports, and given the current difficulties being widely experienced with the latest version of the CLEA Software. Where new SGVs have been released, they have been used in this report.

Discussions should be undertaken with the Local Authority Contaminated Land Officer regarding any new requirements which may arise as the development progresses and this report should be re-visited as and when new SGVs and other pertinent guidance documents are released.

7 Conclusions

7.1 Contamination Risk Summary

In general, across all sites, levels of contamination were higher across Site 3 than Sites 1 and 2. The Norwest Holst 2005 investigation also encountered a wider range of contaminants across Site 3 than the 2009 ground investigation. The following contaminants were identified at elevated levels: Site 1 – Mercury, PAH, aromatic TPH; Site 2 – Aromatic TPH; and Site 3 – Copper, lead, zinc, mercury, PAH, aliphatic and aromatic TPH. These contaminants pose a potential risk to human health if allowed to come into direct contact with humans due to their toxic properties.

Statistical analysis of Norwest Holst 2005 and 2009 ground investigation data identified outliers (hotspots) of contamination, not belonging to the underlying distribution (see Table 6.4). These hotspots require removal and off-site disposal / remediation for each potential end use to remove unacceptable risks to human health. Fewer hotspots exist for Commercial / Industrial end use than for Residential end uses.

Further data analysis identified site-wide elevations across Site 3 (see Table 6.5) of certain banded aromatic hydrocarbons and benzo(a)pyrene, requiring mitigation / remediation measures for the Site to not represent a significant possibility of significant harm to human health in the context of Part IIA of the Environmental Protection Act 1990 for residential end uses. For residential with and without plant uptake end-uses there is a site wide elevation across Site 3 of certain TPH aromatics and benzo(a)pyrene, which will require specific mitigation / remediation measures for the site to be suitable for these end uses.

The only contaminant exceeding assessment criteria for both leachates and groundwaters was copper. Therefore, it is considered unlikely that site soils are contributing to groundwater contamination in the local area, with the exception of some marginally elevated copper levels, potentially caused by the percolation of rainwater through Made Ground. The nearest receptor (River Tyne), is located ~1km to the south. The site is not considered to pose a risk to the river due to the low levels of contaminants identified, the distance to the river and the poor quality of groundwater within Coal Measures.

Elevated levels of phytotoxic contaminants (substances harmful to plants) were identified across all the Tyne Brewery Sites, including boron, copper, nickel and zinc.

Slightly elevated levels of ground gases (carbon dioxide) were detected during a 12 month gas monitoring exercise which have the potential to accumulate in confined spaces and excavations. In addition, levels of contaminants were identified across the Sites which exceed water supply pipeline recommended guidelines, therefore site soils have the potential to adversely impact water supply services. The presence of elevated levels of contaminants potentially aggressive to concrete (primarily sulphates) have also been identified across the Sites.

7.2 Remediation / Mitigation Options

Please Note: At the time of writing, the EA's CLEA methodology is experiencing a period of readjustment. Changes in documentation have occurred with the withdrawal of Contaminated land Reports (CLR) 7 to 10 and the SGVs.

The EA intend to periodically release new toxicological reports and Soil Guidance Values (SGV). Discussions should be undertaken with the Local Authority Contaminated Land Officer regarding any new requirements which may arise as the development progresses and this report should be re-visited as and when new SGVs and other pertinent guidance documents are released.

7.2.1 Human Health

The remediation / mitigation options required for each Site will very much depend on the final end use selected and will be determined by the final Masterplan. Specific measures for individual plots of land cannot be recommended until the Masterplan is finalised. Undertaking remediation / mitigation prior to this may result in an overly conservative approach and / or abortive work being undertaken.

Table 6.6 and Table 6.7 outline in detail the remediation / mitigation required for the following end uses: Residential With Gardens; Residential Without Gardens; and Commercial / Industrial. Remediation / mitigation measures necessary will require consultation with the EA and LA.

To summarise, risks to human health will be primarily mitigated by the removal of contamination hotspots (as detailed in Table 6.8) and the provision of physical barriers between future site users and on site soils through the extensive areas of buildings and hardstanding, and the use of suitable soil capping layers. Specifically for Site 3, for Residential with Gardens End Use, a thicker layer of capping will be required (750mm subsoil and 150mm topsoil) given the higher levels identified across this Site in comparison to Sites 1 and 2. Gas mitigation measures will be required in all buildings (Gas Characteristic Situation 2).

Following removal of hotspots and prior to the re-development of the Tyne Brewery Sites, validation testing will be required to confirm the removal of identified contaminants. A general overview of the validation testing likely to be required is detailed in Table 6.8.

It is recommended that any short-term Site uses are of a commercial / industrial nature only. The remediation / mitigation required for temporary residential accommodation or other similarly sensitive end uses would be prohibitively expensive for a short term use if the final end use of the site is decided to be commercial / industrial in that area.

7.2.2 Controlled Waters / Environment

Given that site soils are not considered to be adversely impacting groundwater and groundwater quality in the local area is considered to be poor, the following mitigation measures are deemed to be sufficient for the protection of groundwaters beneath the site and the River Tyne:

- Localised removal of hotspots as identified in Table 6.4 for off-site disposal / remediation;
- Provision of hardstanding and buildings across large parts of site;
- Isolation of all building and hardstanding area drainage from Made Ground (infiltration drainage is not considered suitable at this site); and
- Provision of suitable thicknesses of clean capping materials in gardens / landscaped areas and use of an underlying geotextile membrane.

7.2.3 Trees and Shrubs

The contamination risks to trees and shrubs should be primarily mitigated through the removal of contamination hotspots, use of suitable capping layers and the potential provision of tree pits for particularly large, deep-rooted trees.

7.2.4 Structures

To mitigate against the elevated levels of carbon dioxide identified, gas mitigation measures suitable for Gas Characteristic Situation 2 will be required. In addition, consultation with the statutory water supplier should be undertaken regarding the need to install protective potable water supply piping across the sites. Given the presence of elevated levels of contaminants potentially aggressive to concrete (primarily sulphates), it is recommended that during the design stage, an appropriate concrete class is selected to withstand any potential chemical attack.

7.2.5 Waste

The Waste Acceptance Criteria test results for Made Ground samples collected from borehole BH201, BH204, BH304 and BH306 have characterised the Made Ground as stable non hazardous waste. Any soils requiring disposal off site disposal should be disposed of to a suitably licensed non hazardous landfill. As best practice, every effort should be made to avoid disposal of material to landfill.

7.3 Contaminated Land Strategy

The below outlines the recommended Strategy to be followed in order to facilitate the re-development of the site.

1. Finalisation of Masterplan and selection of final end uses for each individual plot of Sites 1, 2 and 3 to enable the determination of the levels of remediation / mitigation required.

2. Selection of short term end uses for the site and suitable areas for such short term end uses.

3. Liaison with EA and LA over the exact remediation and mitigation required for each part of the site to be fit for use.

4. Remediation and / or mitigation of the site on a plot by plot basis to the level required for each plot's individual end use (short or long term).

5. Liaison with EA and LA regarding the specific validation testing requirements and reporting required for the site.

6. Completion of validation testing and production of validation reports.

7. Acquisition of approval from EA and LA and sign-off of any pertinent planning conditions.

8. Re-development of the site.

8 References

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- Environment Agency, 1:100,000 scale Groundwater Vulnerability Sheet 5 (Tyne and Tees).
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- John Hellens Contracts Ltd, 'Demolition File for Demolition Works to Former Tyne Brewery, Sites 1/3', June 2009
- Landmark Envirocheck Report, No. 8422401-1-1, January 2005
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- Mott MacDonald, 'Tyne Brewery, Site Development Desk Study No. 2', July 2005

- Norwest Holst, 'Report on a Ground Investigation at Scottish and Newcastle Brewery, Newcastle', October 2005.

- Norwest Holst, 'Tyne Brewery Newcastle Upon Tyne, Addendum Report on Additional Gas Monitoring Results', August 2007.

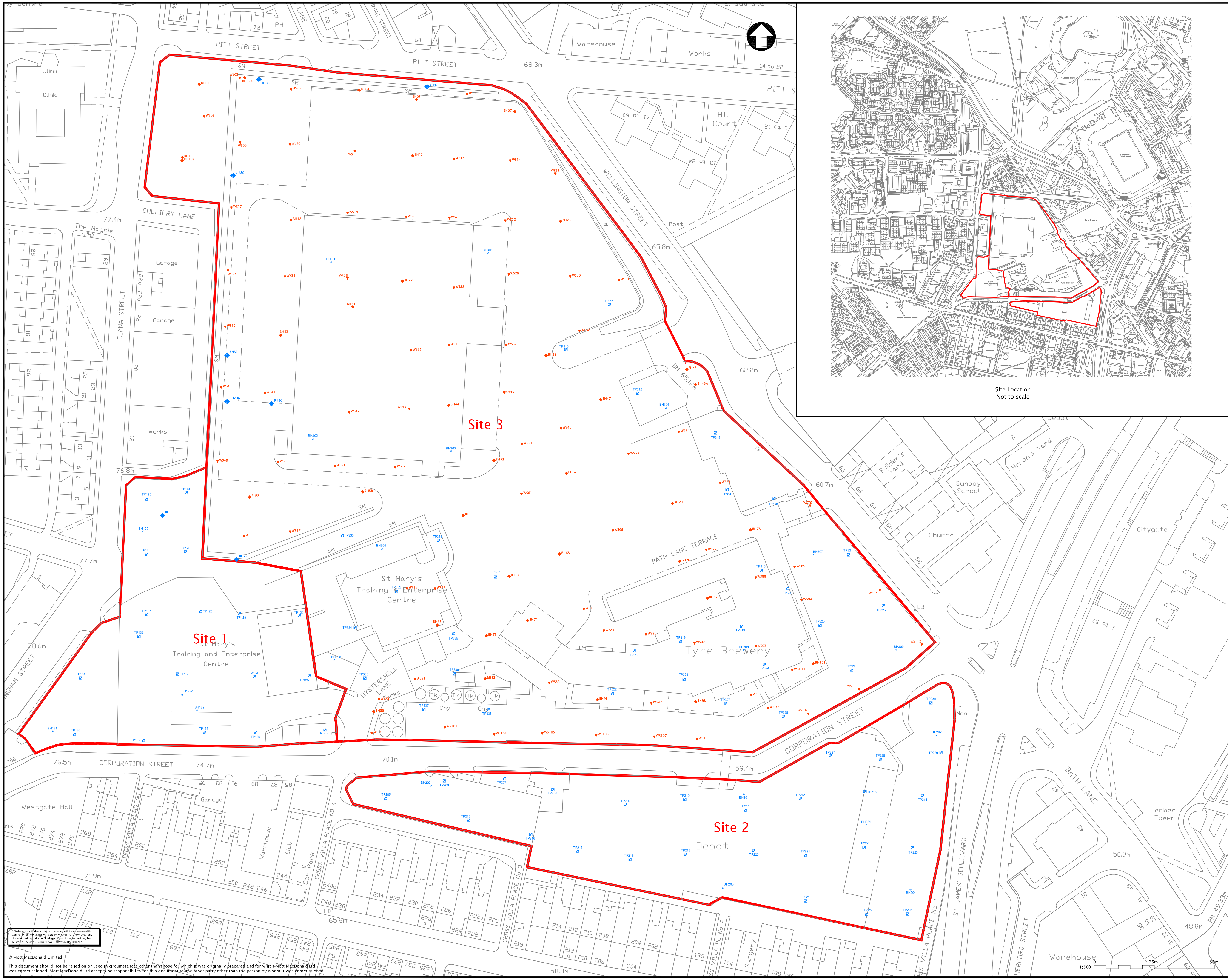
- Norwest Holst, 'Report on a Ground Investigation at the Former Tyne Brewery, Newcastle Upon Tyne, Sites 1 and 2', June 2009.

- Norwest Holst 'Report on a Ground Investigation at the Former Tyne Brewery, Newcastle Upon Tyne, Site 3', June 2009.

- Water Regulations Advisory Scheme, Information and Guidance Note, No 9-04-03 Issue 1, 'The Selection of Materials for Water Supply Pipes to be Laid in Contaminated Land', October 2002.

Appendix A Site Location Plan

Drawing 225057/3012 (Reduced to A3)



Notes

1. All structures on site now demolished and site cleared
2. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Previous ground investigation locations

BH05	Borehole 2005
WS15	Window Sample 2005
BH120	Borehole 2009
TP126	Trial Pit 2009

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Tel +44 (0)191 261 0866
Fax +44 (0)191 261 1100
Web www.mottmac.com

Client
Newcastle City Council

Title
Former Tyne Brewery
Site Location and
Previous Ground Investigation Plan

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	

Scale at A0: 1:500	Project: 225057; CAD file: L0-Cad\3012	Status: PRE
Drawing No: 225057/3012		Rev: P1

Appendix B Consultation

Response from Newcastle City Council Contaminated Land Officer

Newcastle City Council

S.P. Savage, Head of Public Health & Environmental Protection
Regeneration Directorate
Civic Centre, Newcastle upon Tyne, NE1 8PB
Tel: (0191) 232 8520, ext. 26141. Fax: (0191) 211 4962
E-Mail: phep@newcastle.gov.uk www.newcastle.gov.uk

Our Reference: PHEP/HSW/CL/CPH/
Your Reference SZC/STL/225057/D

16 June 2006

Simon Longshaw
Mott McDonald
St Ann's Wharf
112 Quayside
Newcastle upon Tyne NE1 3DX

Dear Sir,

Re: Tyne Brewery - Sites 1, 2 and 3.

I refer to your letter of 9 June 2006 and out telephone conversation on 15th June 2006 regarding the above site.

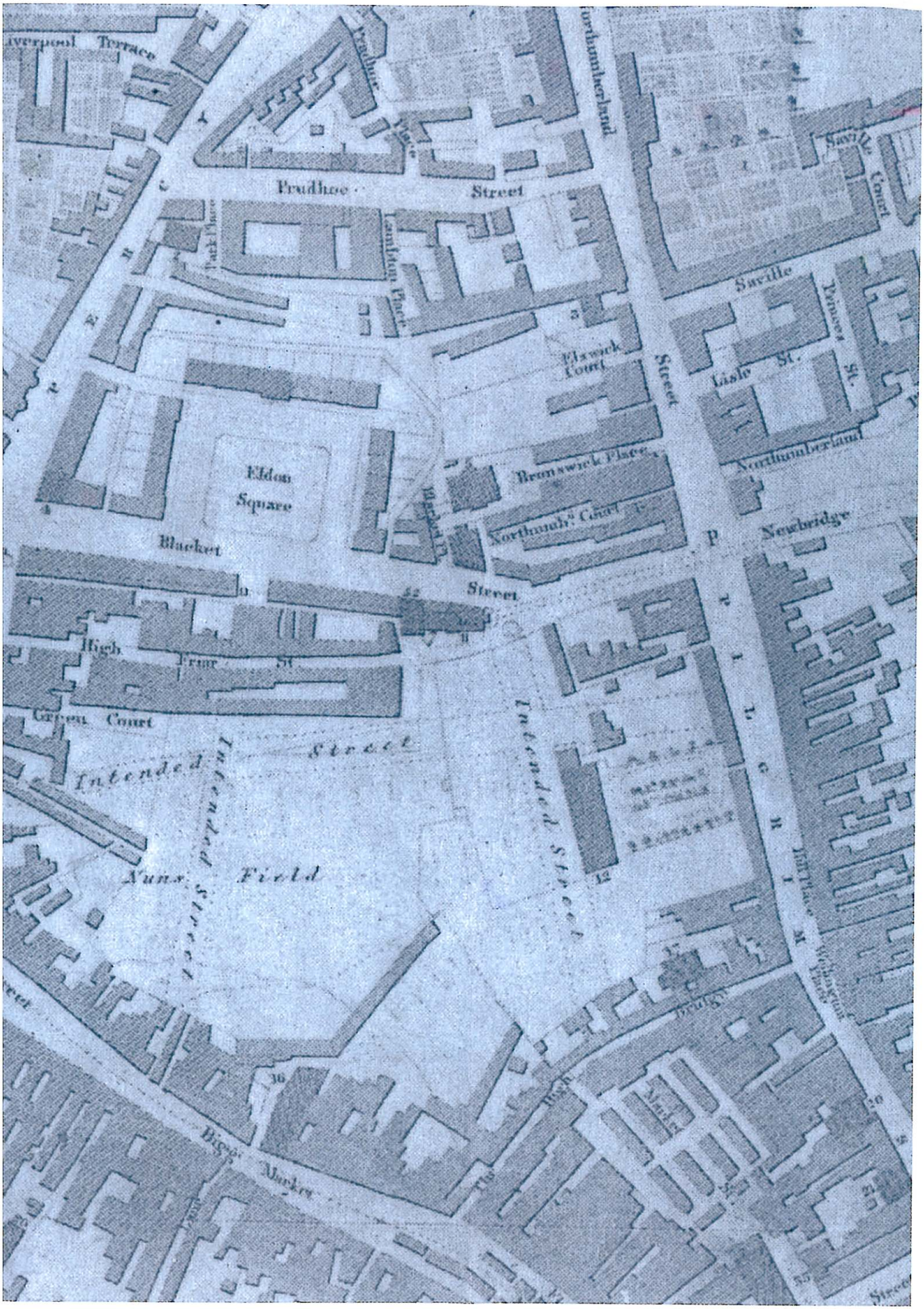
I am not aware of any specific information which we hold for the site other than that available on historic OS mapping and BGS data etc. We do have 1:500 Town Plans which you may not be able to access and historic aerial photography which may be of use. I enclose extracts from John Wood's map of Newcastle 1827 and Charles Hutton's of 1770. You should be able to locate the approximate position of some of the site.

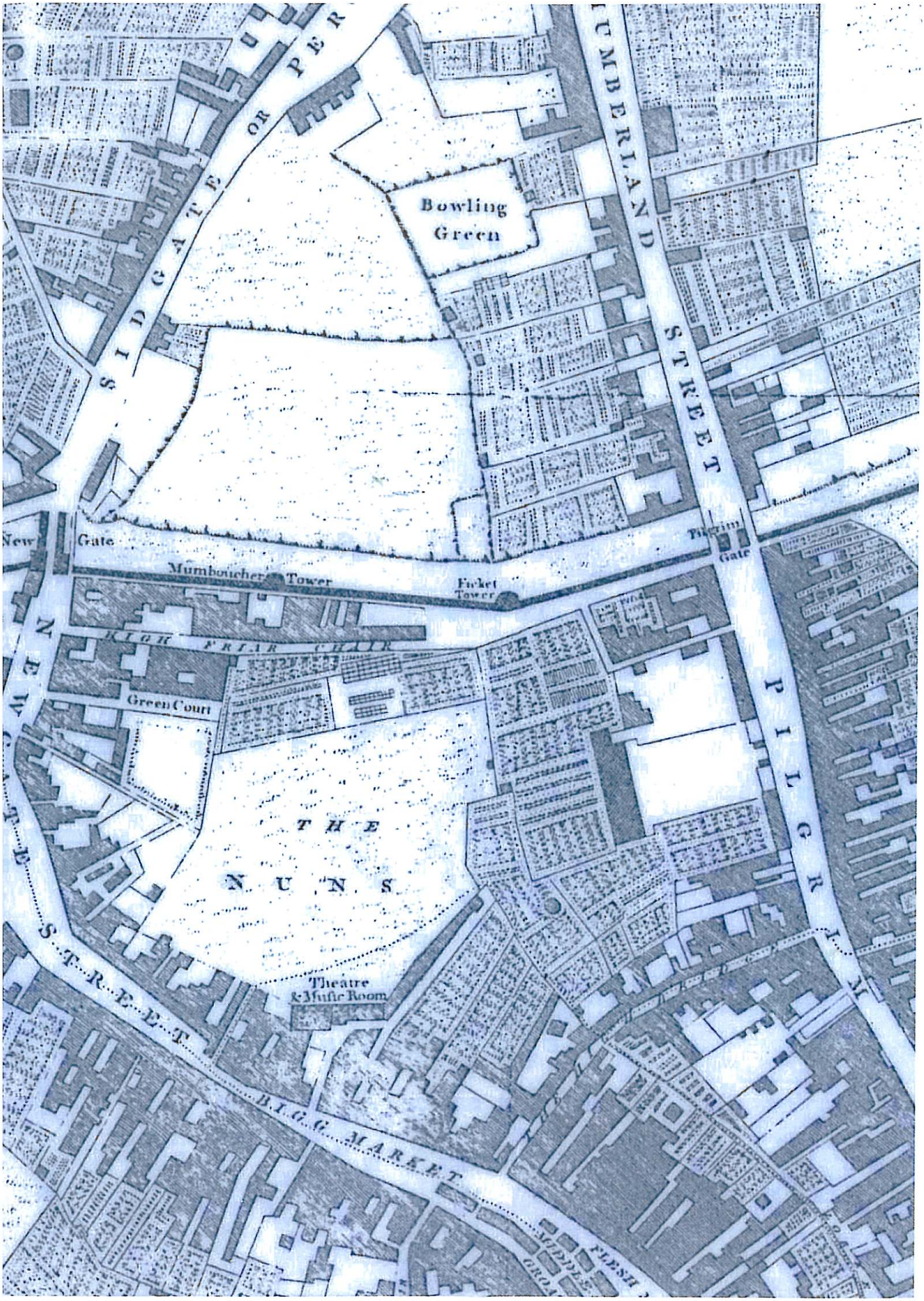
We would like to be involved with the investigation and remedial process for these sites and I would be grateful if you would keep me informed as to developments.

I look forward to hearing from you.

Yours faithfully

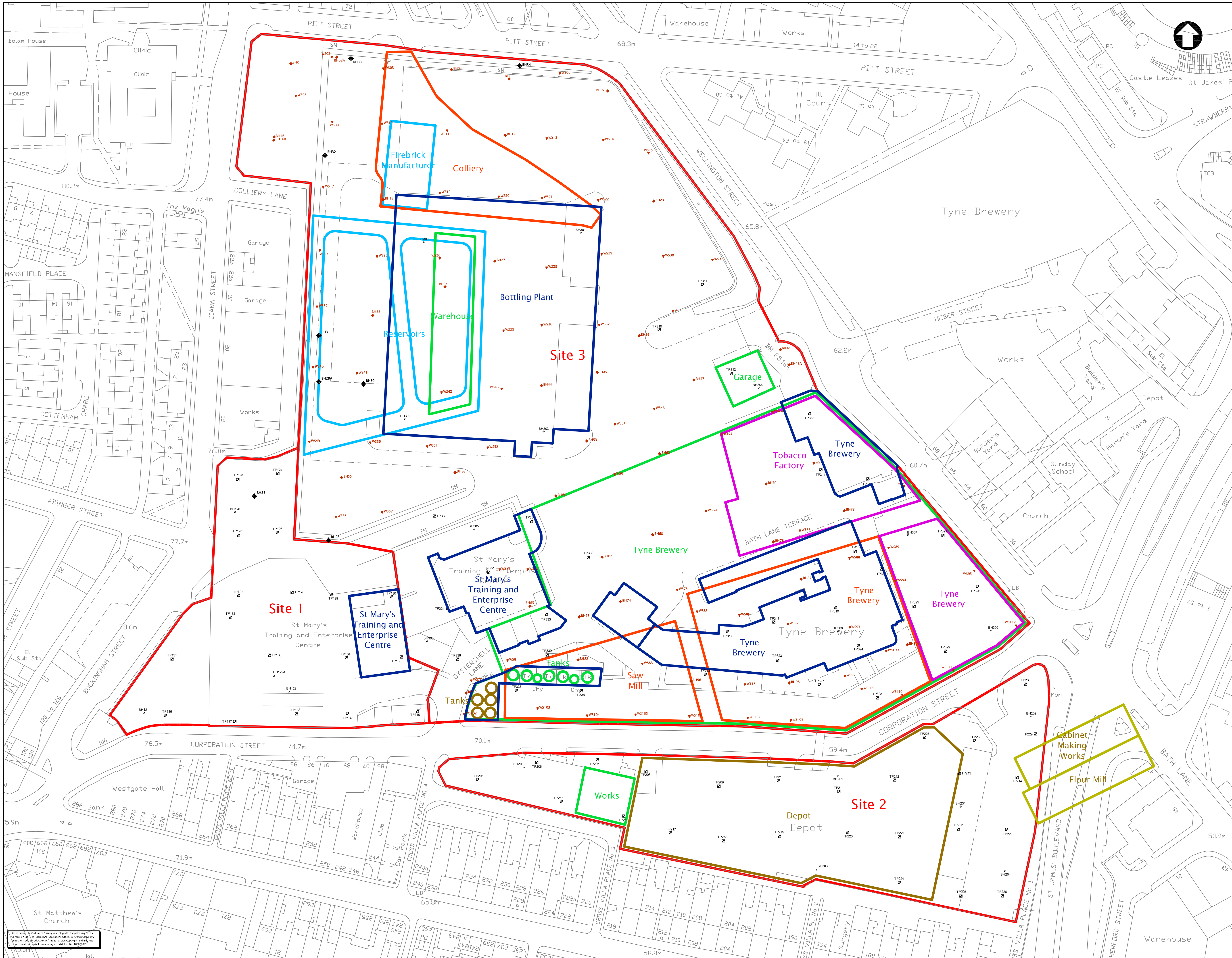
Team Manager


Liverpool Terrace
Pradhoe Street
Northumberland
Swinton Place
Lambton Place
Swinton Court
Saville
Prince's St.
Eldon Square
Blacket Place
Brunswick Place
Northumb.d Court
Eldon Street
Northumberland
Blacket
Street
Newbridge
High Friar St.
Grieve Court
Intended Street
Nuns Field
Intended Street
Intended Street
Bigg Market
Mark
Street


Bowling Green
Gate
Tower
Ticket Tower
Pilgrim Gate
Green Court
THE NUNS
Theatre & Music Room
PILGRIM
STREET
BIG MARKET

Appendix C Historical Land Use Drawing

Drawing 225057/3003 (Reduced to A3)



Notes

1. Source of historical map data: Landmark Envirocheck Report 8422401-1-1 January 2005
2. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Potentially Contaminative Historical Land Uses

- 1861
- 1919
- 1940
- 1950
- 1969-70
- 1988
- 2007 (prior to demolition)

Ground Investigation Locations

- BH05 Borehole 2005
- WS15 Window Sample 2005
- BH120 Borehole 2009
- TP126 Trial Pit 2009

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Web www.mottmac.com

Client

Newcastle City Council

Title

Former Tyne Brewery
Potentially Contaminative Historical Land Uses

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	

Scale at A0 1:500	Project 225057 CAD file L0-Cad\3003	Status PRE
Drawing No 225057/3003		Rev P1

Appendix D Norwest Holst Assessment Criteria 2009

Table D.1: Norwest Holst Soil Assessment Criteria 2009

Determinant	Land Use Scenario (mg/kg)		
	Residential with Plant Uptake (mg/kg)	Residential Without Plant Uptake (mg/kg)	Commercial / Industrial (mg/kg)
Metals, semi- metals and non-metals			
Arsenic	32*	32*	640*
Cadmium	1-8	30	1400
Copper	111	2080	45700
Chromium	130	200	5000
Lead	450	450	750
Mercury	1*	1*	26*
Nickel	130	130	1800
Selenium	350	350	13000
Vanadium	140	150	4250
Zinc	330	8250	188000
pH	NC	NC	NC
PAH			
PAH (total)	NC	NC	NC
Individual compounds:			
Naphthalene	3.47	6.94	290
Acenaphthylene	3.47	6.94	290
Acenaphthene	3.47	6.94	290
Fluorene	3.47	6.94	290
Phenanthrene	3.47	6.94	290
Anthracene	3.47	6.94	290
Fluoranthene	3.47	6.94	290
Pyrene	3.47	6.94	290
Benzo(a)anthracene	3.47	6.94	290
Chrysene	3.47	6.94	290
Benzo(b)fluoranthene	3.47	6.94	290
Benzo(k)fluoranthene	3.47	6.94	290
Benzo(a)pyrene	1.12	1.3	29.7
Dibenz(a,h)anthracene	1.12	1.3	29.7
Indeno(1,2,3)perylene	3.47	6.94	290
Benzo(g,h,i)perylene	3.47	6.94	290
VOC			

Determinant	Land Use Scenario (mg/kg)		
	Residential with Plant Uptake (mg/kg)	Residential Without Plant Uptake (mg/kg)	Commercial / Industrial (mg/kg)
Tetrachloroethane	0.562	3.6	150
TPH			
TPH(total)	NC	NC	NC
TPH C6-C10	0.575	0.613	26.9
TPH C10-C21	1.94	14.2	625
TPH C21-C40	157	417	9250
Aliphatic EC5-C6	2.11	2.11	95.3
Aliphatic >EC6-C8	5.37	5.37	242
Aliphatic >EC8-EC10	1.46	1.46	65.9
Aliphatic >EC10-EC12	8.53	8.60	29900
Aliphatic >EC12-EC16	40.7	42.1	29900
Aliphatic >EC16-EC35	1640	27600	617000
Aliphatic >EC35-EC44	1640	27600	617000
Aromatic >EC5-EC7	0.33	0.613	26.9
Aromatic >EC7-EC8	0.624	0.694	30.4
Aromatic >EC8-EC10	1.09	2.39	107
Aromatic >EC10-EC12	1.94	14.2	625
Aromatic >EC12-EC16	2.19	72.7	12200
Aromatic >EC16-EC21	115	291	9190
Aromatic >EC21-EC35	157	417	9250
Aromatic >EC35-EC44	157	417	9250
Other			
Organic Matter(%)	1	1	1
Cyanide Total	NC	NC	NC
Asbestos	NC	NC	NC

- CLEA SGV or LQM GAC for residential with plant uptake use scenario at 1% organic matter content
- Mean and max value test only carried out where reference level exceeded.
- Dutch values for Cyanide complex ≥pH5 used for Total Cyanide
- NC = No criterion
- CLEA SGV published March and May 2009
- LQM/CIEH GAC for Naphthalene adopted as a conservative assessment criteria for speciated PAH

Table D.2: Norwest Holst Leachate/Groundwater Assessment Criteria 2009

Determinant	Water Quality Standards (µg/l)	
	Environmental Quality Standards (saltwater)	Drinking Water Quality Standards
Metals and semi- metals		
Arsenic	25	10
Boron	7000	1000
Cadmium	2.5	5
Chromium	15	50
Copper	5	2000
Lead	25	25*
Nickel	30	20
Selenium	NC	10
Zinc	NC	3000
Mercury (inorganic)	0.3	1
Vanadium	100	NC
Cyanide (free)	NC	50
Organics		
Phenols	30	0.5
TPH	NC	10
Naphthalene	10	-
PAH (4a)	-	0.1
Benzo(a)pyrene	-	0.01
BTEX	30	1
Others		
Ammonia (Free)	21	NC
Chloride	250000	-
Fluoride	NC	1500
Sulfate	250000	250000
pH	6-9	5.5-9.5

- NC = No criteria available
- All assessment criteria and results in µg/kg
- ND = None Detected
- (4) a ~ = PAH drinking water quality value for the sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(1, 2, 3-cd)pyrene.

Appendix E Contamination Testing Results - Exceedences

CD Provided of Chemical Testing Data

Appendix F Areas of Assessment Criteria Exceedance Drawings

Drawing 225057/3004 (Reduced to A3)

Drawing 225057/3005 (Reduced to A3)

Drawing 225057/3006 (Reduced to A3)

Drawing 225057/3007 (Reduced to A3)

Drawing 225057/3008 (Reduced to A3)

Site 1

Site 2

Site 3

Tyne Brewery

St Mary's Training and Enterprise Centre

Notes

1. This drawing combines the results from the Norwest Holst 2005 and 2009 ground investigations.
2. The screening level exceedances for TPH use very conservative limits (assumption is that all TPH present in that screening group is present as the lowest carbon chain aromatic). Therefore, following speciated testing it is considered many would not fail TPHCWG banded limits
3. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Soil Exceedances

- Inorganics
- TPH (Banded)
- PAH/BTEX
- Screening level exceedances for TPH >C6-C10 and/or C10-C21 and/or C21-C40
- BH05 Borehole 2005
- WS15 Window Sample 2005
- BH120 Borehole 2009
- TP126 Trial Pit 2009
- Cu Copper
- Pb Lead
- Zn Zinc
- Hg Mercury
- ARO TPH Aromatics
- ALI TPH Aliphatics
- BaP Benzo(a)pyrene
- Dibenz Dibenzo(ah)anthracene
- Napth Napthalene

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Fax +44 (0)191 261 1100
Web www.mottmac.com

Client: Newcastle City Council

Title: Former Tyne Brewery
Soil Exceedances For
'Residential with Gardens' End Use

Designed	N Berry		Eng.Chk.	A Lawrence	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	
Scale at A0	1:500	Project	225057		Status PRE
		CAD file	L0-Cad\3004		
Drawing No	225057/3004				Rev P1

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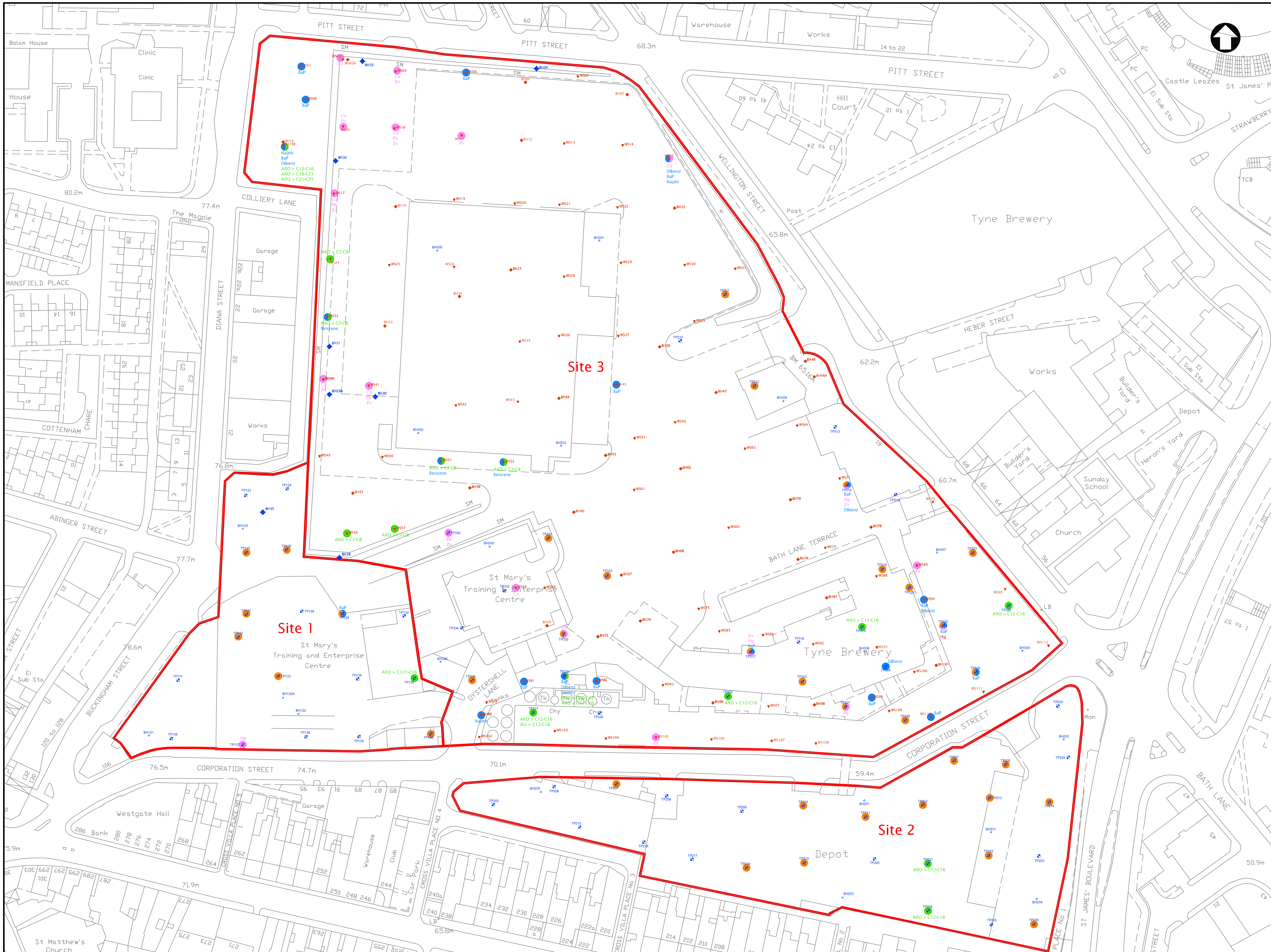

Notes

1. This drawing combines the results from the Norwest Holst 2005 and 2009 ground investigations.
2. The screening failures for TPH use very conservative limits(assumption is that all TPH present in that screening group is present as the lowest aromatic). Therefore, following speciated testing it is considered many would not fail
3. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Soil Exceedences

Symbol	Meaning
(pink circle)	Inorganics
(green circle)	TPH (Banded)
(blue circle)	PAH/BTEX
(orange circle)	Screening failures for TPH >C6-C10 and/or C10-C21 and/or C21-C40
BH05	Borehole 2005
WS15	Window Sample 2005
BH120	Borehole 2009
TP126	Trial Pit 2009
Cu	Copper
Pb	Lead
Zn	Zinc
Hg	Mercury
ARO	TPH Aromatics
ALI	TPH Aliphatics
BaP	Benzo(a)pyrene
Dibenz	Dibenzo(a.h)anthracene
Napth	Napthalene
Benzene	Benzene

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Web www.mottmac.com

Client

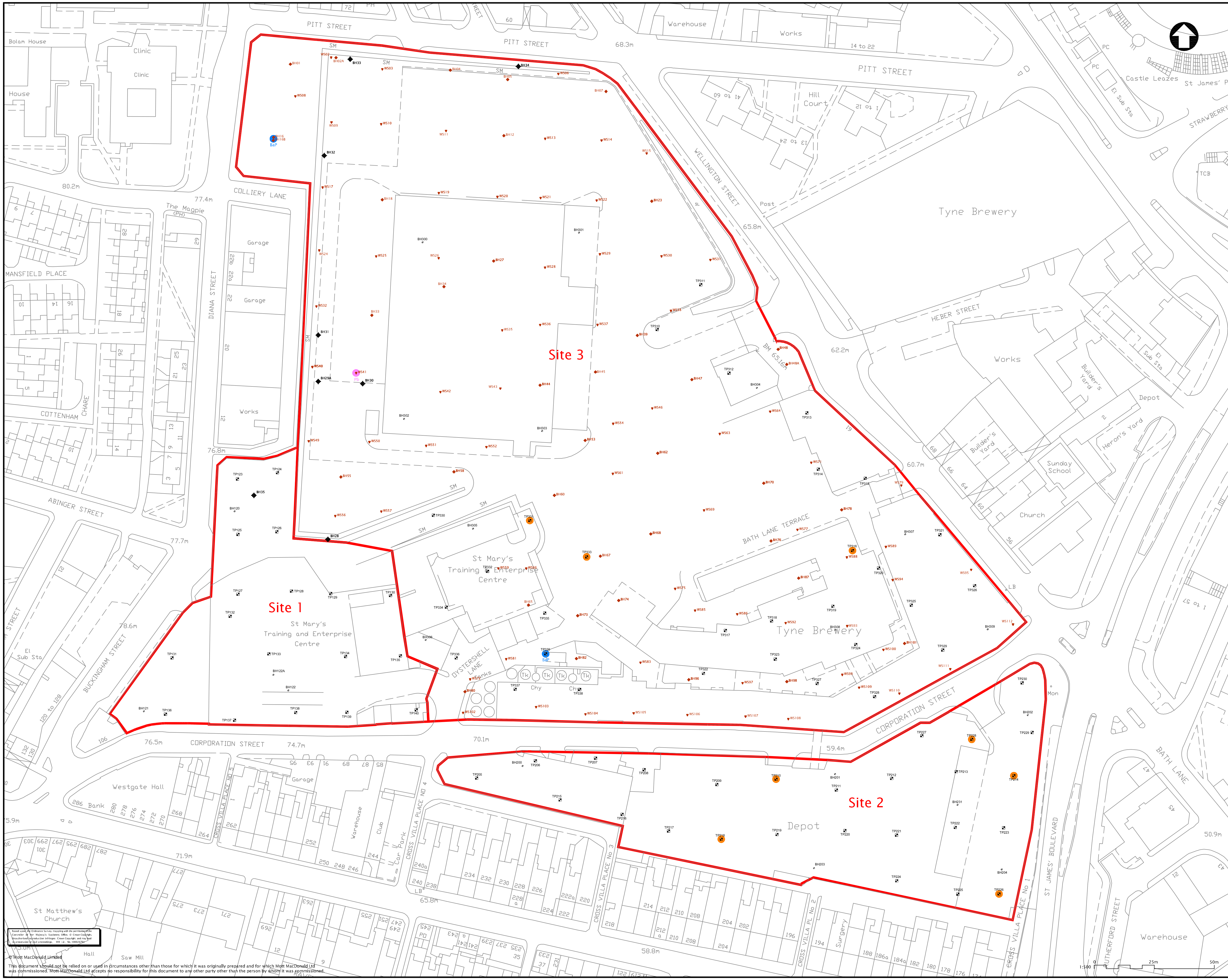
Newcastle City Council

Title

Former Tyne Brewery
Soil Exceedences -
End Use
'Residential no Gardens'

Designed	N Berry		Eng.Chk.	A Lawrance
Drawn	D Bovill		Coordination	
Dwg.Chk.	N Berry		Approved	S Longshaw

Scale at A0: 1:500	Project: 225057 / CAD file: L0-Cad\3005	Status: PRE
Drawing No: 225057/3005		Rev: P1



Notes

1. This drawing combines the results from the Norwest Holst 2005 and 2009 ground investigations
2. The screening failures for TPH use very conservative limits (assumption is that all TPH present in that screening group is present at the lowest aromatic). Therefore, following speciated testing it is considered many would not fail
3. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Soil Exceedances

- Screening
- Inorganics
- PAH
- BH05 Borehole 2005
- WS15 Window Sample 2005
- BH120 Borehole 2009
- TP126 Trial Pit 2009
- Pb Lead
- BaP Benzo(a)pyrene

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Web www.mottmac.com

Client
Newcastle City Council

Title
Former Tyne Brewery
Soil Exceedances for
Commercial/Industrial End Use

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	

Scale at A0: 1:500
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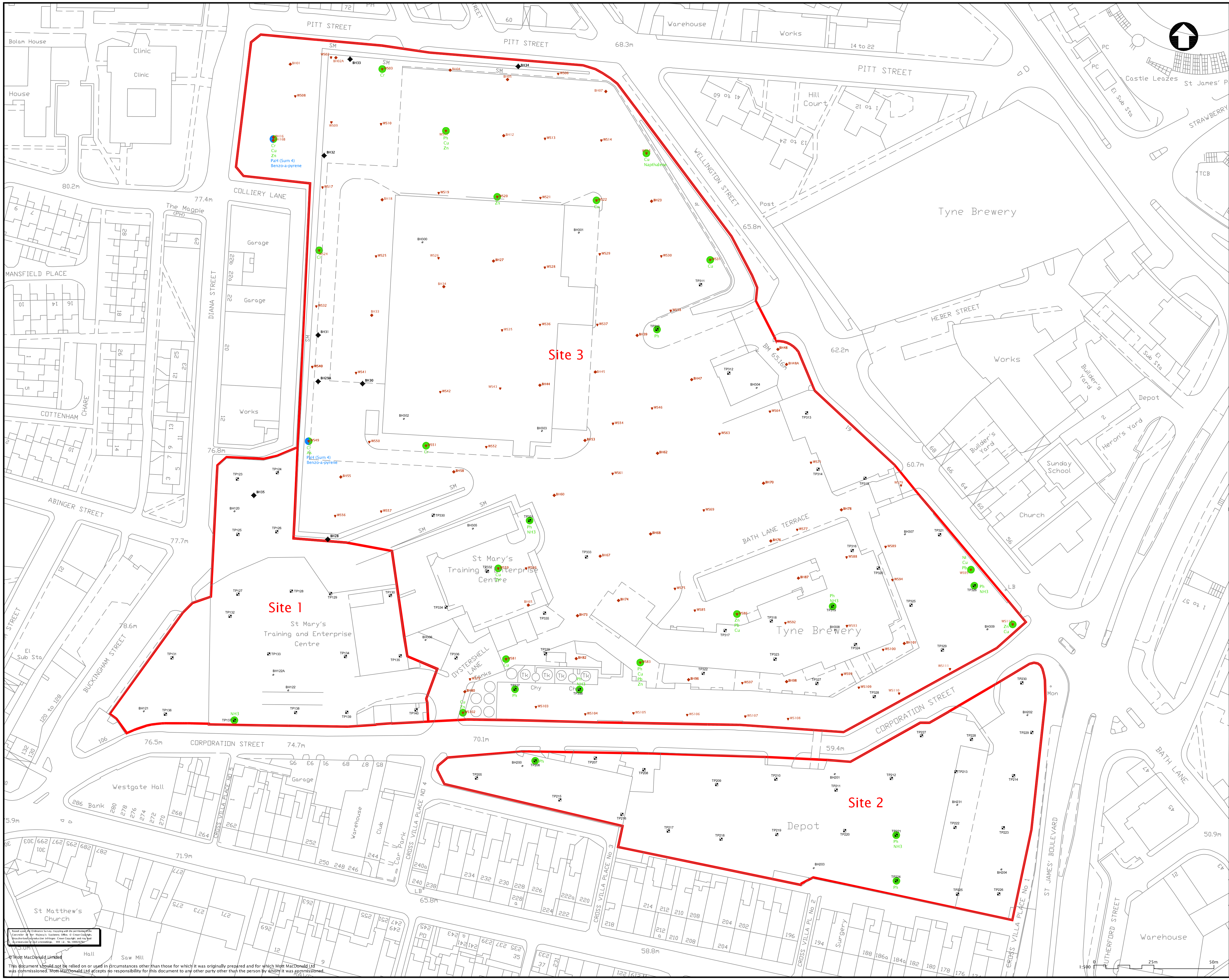
CAD file: L0-Cad\3006
Status: PRE
Drawing No: 225057/3006
Rev: P1



Notes

1. This drawing combines the results from Norwest Holst 2005 and 2009 ground investigations
2. All 2009 locations tested at less than the detection limits for mercury, BaP and total PAH. However as these limits slightly exceed the assessment criteria, all have the potential to marginally fail
3. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Groundwater Exceedences

- Green circle: EQS Exceedances (Environmental Quality Standards for saline waters)
- Blue circle: DWS Exceedances. (Drinking Water Standards - used where no EQS avaialble)

Symbol	Meaning
BH05	Borehole 2005
WS15	Window Sample 2005
BH120	Borehole 2009
TP126	Trial Pit 2009
Cu	Copper
Ni	Nickel
As	Arsenic
Cl	Chloride
Pb	Lead
NH3	Ammoniacal Nitrogen

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Web www.mottmac.com

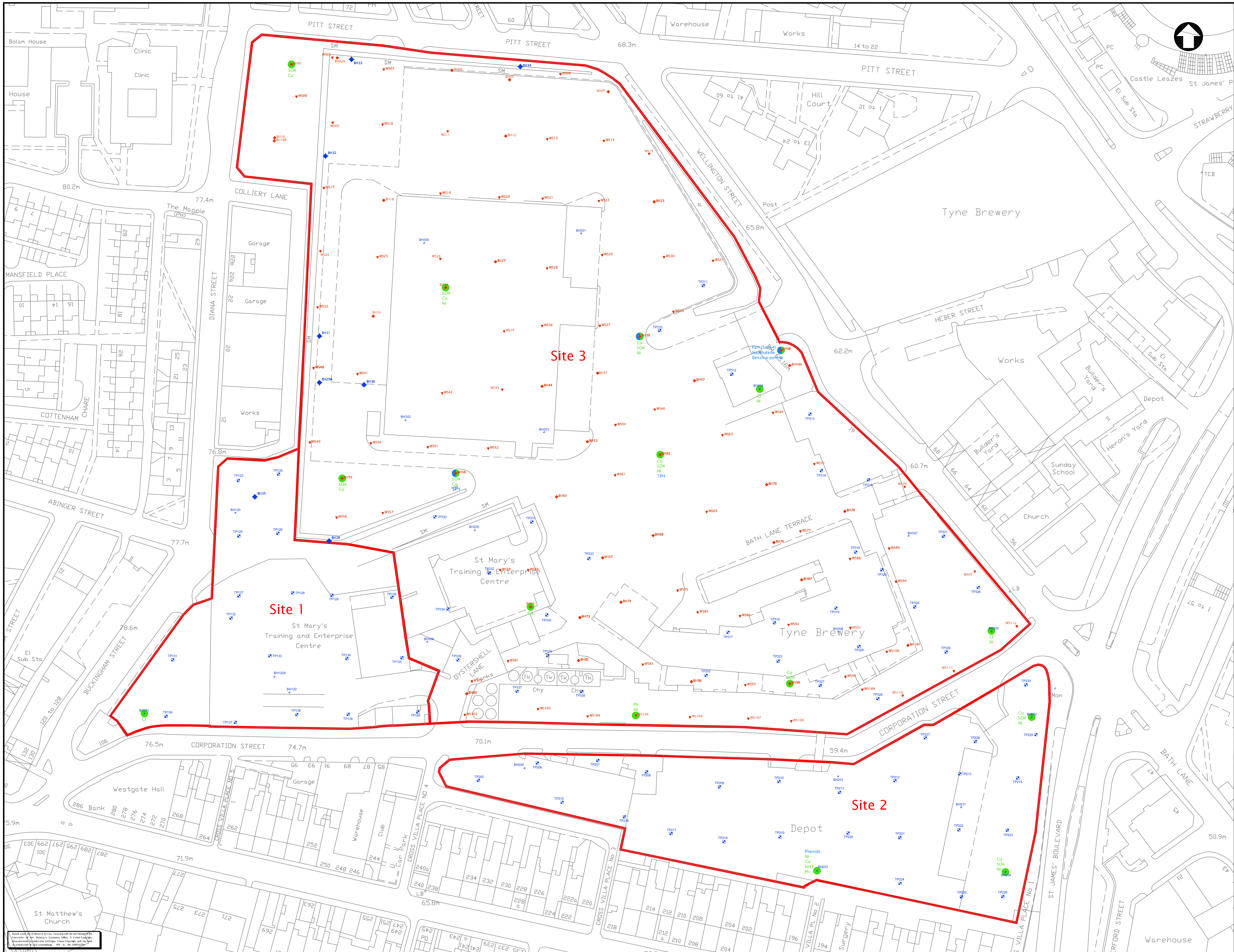
Client: Newcastle City Council

Title: Former Tyne Brewery Leachate Exceedances

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	

Scale at A0: 1:500 | Project: 225057 | CAD file: L0-Cad\3007 | Status: PRE

Drawing No: 225057/3007 | Rev: P1



Notes

1. This drawing combines the results from the Norwest Holst 2005 and 2009 ground investigations.
2. All 2009 locations tested at less than the detection limits for mercury, BaP and total PAH. However, as these limits slightly exceed the assessment criteria, all have the potential to marginally fail
3. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Groundwater Exceedences

- EQS Exceedances (Environmental Quality Standards for saline waters
- DWS Exceedances (Drinking Water Standards - used where no EQS available)

- BH05 Borehole 2005
- WS15 Window Sample 2005
- BH120 Borehole 2009
- TP126 Trial Pit 2009

- Cu Copper
- Ni Nickel
- SO4 Sulphate
- Cl Chloride
- NH3 Ammoniacal Nitrogen
- TPH Total Petroleum Hydrocarbons

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Client
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Title
Former Tyne Brewery
Groundwater Exceedances

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	

Scale at A0 1:500	Project 225057 / CAD file L0-Cad\3008	Status PRE
Drawing No 225057/3008		Rev P1

Appendix G Remediation / Mitigation Option Drawings

Drawing 225057/3009 (Reduced to A3)

Drawing 225057/3010 (Reduced to A3)

Drawing 225057/3011 (Reduced to A3)

Site 1

Site 2

Site 3

Notes

1. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Localised contamination hotspot requiring offsite disposal/remediation

Unsuitable for end use without specific mitigation measures potentially including:
- Bulk removal of materials,
- Provision of impermeable physical barrier; or
- Provision of permeable physical barrier

Localised removal of hotspots for 'Residential with plant uptake end use' required

Validation testing required across Site 3 to include banded hydrocarbon testing in areas of residential with gardens

Garden areas would require a minimum of 750mm imported clean subsoil and 150mm imported clean topsoil

Gas mitigation measures suitable for Characteristic Situation 2 required

Unsuitable for end use without specific mitigation measures potentially including:
- Bulk removal of materials,
- Provision of impermeable physical barrier; or
- Provision of permeable physical barrier

Localised removal of hotspots for 'Residential with plant uptake end use' required

Validation testing required across Sites 1 and 2 to include banded hydrocarbon testing in areas of residential with gardens

Garden areas would require a minimum of 450mm imported clean subsoil and 150mm imported clean topsoil

Gas mitigation measures suitable for Characteristic Situation 2 required

BH05 Borehole 2005 NHGI

WS15 Window Sample 2005 NHGI

BH20 Borehole 2009 NHGI

TP26 Trial Pit 2009 NHGI

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	Appr'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Web www.mottmac.com

Client

Newcastle City Council

Title

Former Tyne Brewery
Remediation/Mitigation
Residential with gardens

Designed	N Berry		Eng.Chk.	A Lawrance	
Drawn	D Bovill		Coordination		
Dwg.Chk.	N Berry		Approved	S Longshaw	
Scale at A0	1:500	Project	225057		Status PRE
		CAD file	L0-Cad\3009		
Drawing No	225057/3009				Rev P1

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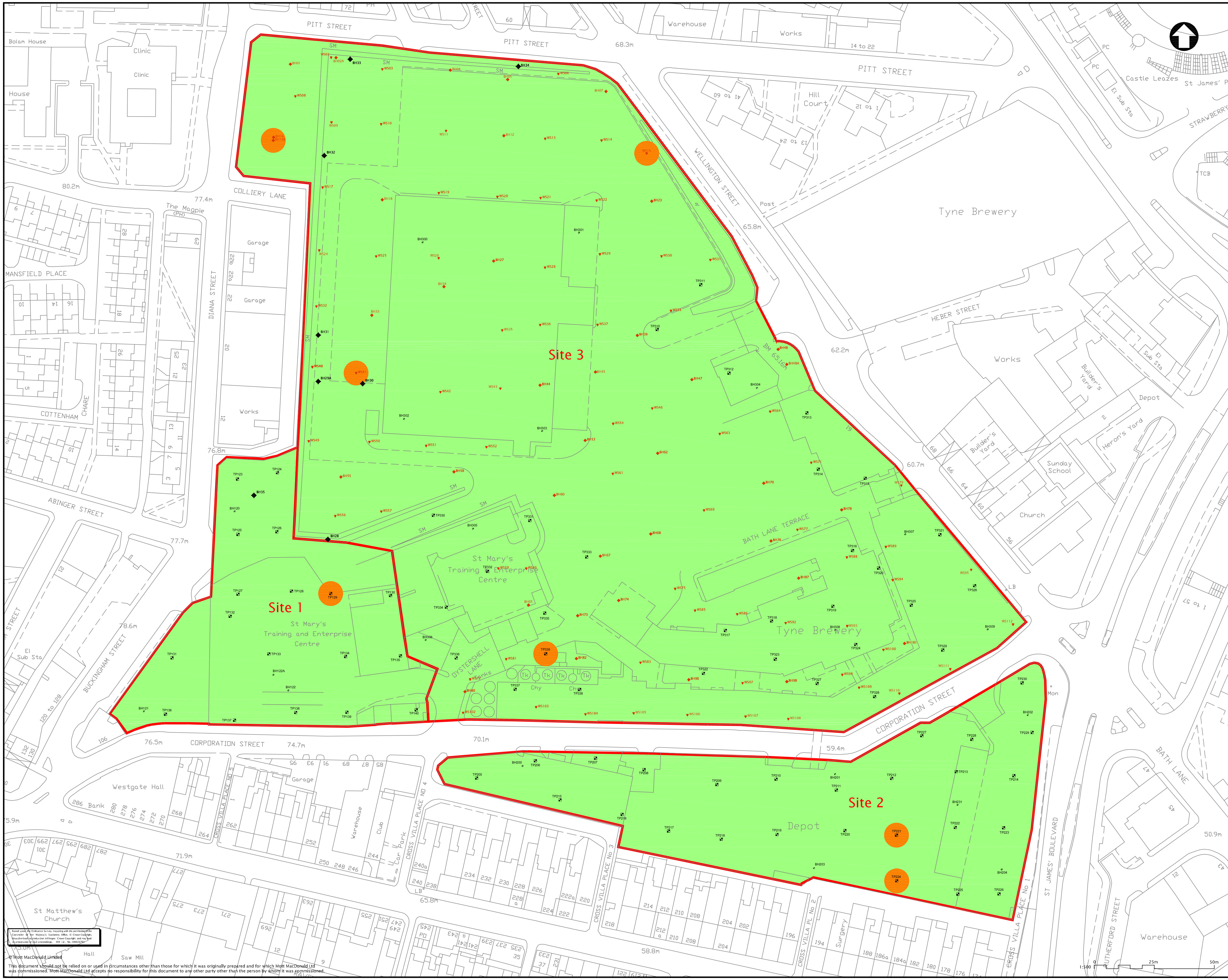

Notes

1. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

- Localised contamination hotspot requiring offsite disposal/remediation
- Localised removal of hotspots for 'Residential without plant uptake end use' required
- Validation testing required across Sites 1, 2 and 3 - to include hydrocarbon testing in landscaped areas
- Landscaped areas would require a geotextile membrane and a minimum of 450mm imported clean subsoil and 150mm imported clean topsoil
- Gas mitigation measures suitable for Characteristic Situation 2 required
- BH05 Borehole 2005 NHGI
- WS15 Window Sample 2005 NHGI
- BH120 Borehole 2009 NHGI
- TP126 Trial Pit 2009 NHGI

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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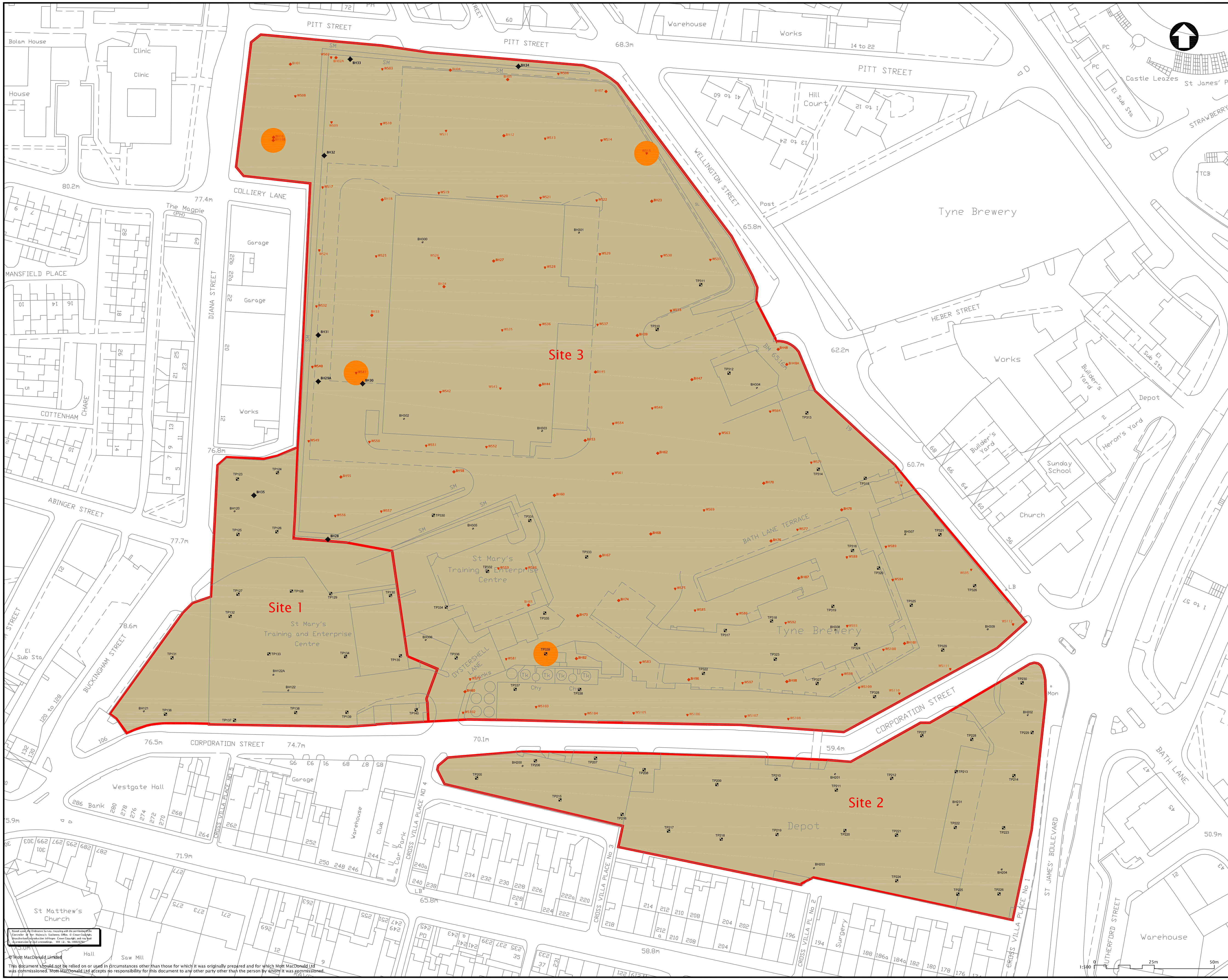
Fax +44 (0)191 261 1100
Web www.mottmac.com

Client: Newcastle City Council

Title: Former Tyne Brewery Remediation/Mitigation Residential without gardens

Designed	N Berry		Eng.Chk.	A Lawrance
Drawn	D Bovill		Coordination	
Dwg.Chk.	N Berry		Approved	S Longshaw

Scale at A0: 1:500
Project: 225057
CAD file: L0-Cad\3010
Status: PRE
Drawing No: 225057/3010
Rev: P1



Notes

1. This drawing should only be used in conjunction with the Mott MacDonald report 'Former Tyne Brewery, Sites 1, 2 & 3, Contaminated Land Strategy, July 2009 and associated tables. It is not intended for use as a stand-alone document

Key to symbols

Localised contamination hotspot requiring offsite disposal/remediation

- Localised removal of hotspots for "Commercial/industrial end use' required
- Validation testing required across Sites 1, 2 and 3
- Landscaped areas would require a geotextile membrane and a minimum of 450mm imported clean subsoil and 150mm imported clean topsoil
- Gas mitigation measures suitable for Characteristic Situation 2 required

BH05 Borehole 2005

WS15 Window Sample 2005

BH120 Borehole 2009

TP126 Trial Pit 2009

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	29.06.09	DLB	Drawing Created	NB	SL

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Client

Newcastle City Council

Title

Former Tyne Brewery
Remediation/Mitigation
Commercial/industrial

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