

**TACK LEA WORKS
BURY**

**PHASE 1 PRELIMINARY
RISK ASSESSMENT,
GEO-ENVIRONMENTAL
INVESTIGATION AND
RISK ASSESSMENT**



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INCREASING LAND VALUE





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CONTENTS

1	INTRODUCTION.....	1
2	SITE HISTORY	2
3	ENVIRONMENTAL SETTING.....	4
4	SITE RECONNAISSANCE	6
5	PRELIMINARY CONCEPTUAL MODEL	7
6	GROUND INVESTIGATION.....	13
7	GROUND CONDITIONS.....	18
8	GENERIC RISK ASSESSMENT	22
9	CONCLUSIONS.....	33
10	REMEDIAL RECOMMENDATIONS	34

FIGURES

Figure 1: Site Location Plan

Figure 2: Site Boundary Plan

Figure 3: Proposed Development Plan

Figure 4: Former Works Site Features

Figure 5: Sampling Location Plan

APPENDICES

Appendix A: Historical Maps

Appendix B: Envirocheck Report

Appendix C: Historical BGS Borehole Data

Appendix D: Coal Authority Report

Appendix E: Site Reconnaissance

Appendix F: Risk Matrix

Appendix G: Profile Logs

Appendix H: Certificate of Analysis – Soil

Appendix I: Certificate of Analysis – Geotechnical

Appendix J: Certificate of Analysis – Water

Appendix K: Gas Monitoring Results

Appendix L: Generic Assessment Criteria Values

Appendix M: Typical Environmental Cover System

1 INTRODUCTION

1.1 Background

LK Consult Ltd (LKC) has been commissioned to carry out a Phase 1 Preliminary Risk Assessment (PRA) and Interpretive Ground Investigation Report for Tack Lea Works, Bury. The report was undertaken in support of a future planning application to redevelop the site for residential properties.

According to guidance set out in CLR11¹, GPLC1-3² and the National Planning Policy Framework (NPPF)³ a PRA with a site reconnaissance is required as a minimum to ascertain if there is a potential contamination risk.

In accordance with current guidance, the PRA will include a site reconnaissance, site history, geology, hydrogeology, hydrology, mineral search and a landfill search. Information gathered from the desk study and site reconnaissance will be used to develop a contamination conceptual model for the site, which will support the identification and assessment of any pollutant linkages.

LKC has also carried out a site investigation has been undertaken to confirm the ground conditions below the site to allow a contamination and geotechnical assessment to be undertaken.

The investigation will aim to confirm the risks of the potential pollutant linkages identified in the PRA and recommend further assessment / remediation, as required.

1.2 Site Details

A summary of site details are presented in Table 1-1. Figures 1 and 2 indicate the site location and boundary. Figure 3 indicates the proposed development.

Location	North of Bury and Rochdale Old Road, Heywood, Bury. Centred at approximate National Grid Reference 383930E 412060N.
Area	1.02ha.
Topography	130-140 metres above ordnance datum (AOD). Site is approximately level. However, the site boundaries are elevated above the site in the southwest of the site and along the northern boundary.
Current Land Use	<u>Site</u> Hardstood ground across the majority of the site with dense vegetation in the north, south and west of the site. A reservoir is present in the north of the site. Works buildings are present across the centre of the site. <u>Surrounding Area</u> North: Farm land associated with Lower Tack Lea Farm. East: Residential properties. South: Bury and Rochdale Old Road, and Woodland beyond. West: Woodland.
Proposed Development	Residential properties with gardens.

Table 1-1: Summary of site details.

¹ EA (2004). "Model Procedures for the Management of Land Contamination." R&D Publication CLR 11.

² EA (2010) "Guiding Principles for Land Contamination." GPLC1-3.

³ DCL (2012). "National Planning Policy Framework." Department of Communities and Local Government. March 2012.

2 SITE HISTORY

2.1 Historical Map Review

In compiling the site history, LKC consulted historical mapping provided by the Landmark Information Group Ltd. Copies of relevant historical plans are provided in Appendix A and are summarised Table 2-1. Notable features within 100m of the site boundary have been presented (distances will be approximate). The exception to this will be features within a 250m buffer that could be infilled historically.

Site Features	Location	Map Dates Present	Comments
Tack Lea Bleach Works / Works	Centre	1894 - present	- Extended to north, east and west by 1910 mapping. Extended eastwards prior to 1930 mapping. Denoted as works from 1963 mapping. - Works extended westwards prior to 1992 mapping onto area of former reservoir. - Anecdotally the Works on site have been related to textile processing and more recently plastic and rubber product manufacture.
Reservoir	NW	1894 -1963	- Extended to north and south by 1910 mapping. No longer present by 1992 mapping.
Reservoir	N	1894 - present	- Extended to north, west and south by 1910 mapping.
Tack Lee Brook	S	1894 - present	- Culverted under the site from 1910 mapping.
Filter Beds	S	1910 - 1911	- No longer present by 1930 mapping.
Cutting / Embankment	Centre	1910 - 1963	- Infilled prior to 1992 mapping.
Tanks	SE	1910 - 1930	- No longer denoted by 1937 mapping.
Unreferenced Building	E	1910 only	- No longer present by 1911 mapping.
Chimney	N	1930 - 1963	- No longer present by 1992 mapping.
Chimney	N	1930 - 1963	- No longer present by 1992 mapping.
Sinks	SW	1963	- Tack Lee Brook sinks in the southwest of the site.
Surrounding Area Features	Distance/ Location	Map Dates Present	Comments
Reservoir	7m NW	1894 - 1984	- No longer present by 1999 mapping.
Reservoir	17m W	1894 - present	
Pond	94m W	1910	- No longer present by 1930 mapping. Pond is not denoted as marshland until 1963 mapping.
Pond	233m NW	1894	- No longer present by 1910 mapping.
Pond	128m S	1851 - 1984	- No longer present by 1999 mapping.
Pond	222m S	1894	- No longer present by 1910 mapping.
Pump	200m S	1894	- No longer present by 1910 mapping.
Well	232m S	1851	- No longer present by 1894 mapping.
Spring	75m SE	1910	- No longer present by 1930 mapping.
Cutting	16m SE	1930 - 1984	- No longer present by 1999 mapping.
Reservoir	233m NW	1894	- No longer present by 1910 mapping.
Reservoir	232m NW	1894	- No longer present by 1910 mapping.

Table 2-1: Summary of historical features.

2.2 Additional Historical Information

Based on information available in the public domain, a fire is known to have occurred at the Works onsite in April 2006. At the time of the fire, the Works on site was producing plastic products for the highways industry. It was reported in the local media at the time of the fire that the fire started in the yard of the Works and spread to some of the nearby buildings despite the efforts of firefighters.

It is also understood that the site has been vacant and derelict since 2007 when the plastic product manufacturing company previously occupying the site moved to new premises.

A previous Desk Study Assessment was undertaken by Brownfield Solutions Limited (reference AJH/C1194/485 Rev A dated April 2007) and contains a description of the site and processes at the time of operation. These are summarised below and a plan showing pertinent features of the former Works is presented in Figure 4.

- The main concrete yard in the south of the site contained racking for products awaiting dispatch, a container for inks and thinners, a bunded diesel tank and storage for hydraulic oils, inks and thinners.
- The main building consists of a single storey building with a boiler room, a chimney to the rear and a small cellar.
- The internal floors of the buildings were observed to be predominately concrete and were locally in a poor state of repair.
- Internally there was evidence of old fuel tanks close to the boiler house chimney.
- To the north of the main building is an area which anecdotally contained a tank but no information was available on the contents of the tank. Storage of unknown liquids in IBCs were also noted in this area.
- Processes on site involved raw materials (plastics and rubber) heated and then shaped in hydraulic presses and spraying of moulded products. Inks and thinners were used in these processes and in several locations of the former Works.

3 ENVIRONMENTAL SETTING

In compiling this Section, LKC consulted environmental information provided by the Envirocheck Report (Appendix B), British Geological Survey (BGS) (Appendix C), Coal Authority Report (Appendix D), Natural England and the Environment Agency. A summary is presented in Table 3-1.

Categories (data sources)			Details
Geology	Artificial ¹		- None recorded on site.
	Superficial ¹		- Devensian Till
	Bedrock ^{1,2}		- Pennine Lower Coal Measures Formation. - Strata dipping to the south. - 1 fault within 500m located 450m east and striking north-south.
	BGS logs ³		- BH Ref: SD81SW229, 12m SE: made ground to 1.4m, silty clayey sand to 3.5m, clayey sandy cobbles to >4.5mbgl. - BH Ref: SD81SW185, 112m N: topsoil to 0.15m, made ground (backfill) to 0.76m, grey shale (PLCMF) to >60.96mbgl. - BH Ref: SD81SW230, 112m E: made ground to 1.5m, silty clay to 2.0m, sandy silty clay to 5.2m, sand to 5.3m, sandy silty clay to >6.0mbgl.
Hydro-geology	Aquifer Designation	Superficial ¹	- Secondary Undifferentiated.
		Bedrock ¹	- Secondary A.
	Source Protection Zone (SPZ)		- Site is not within an SPZ.
	Groundwater Abstractions ¹		- 6 within 500m. Nearest 112m N at Lower Tack Lea Farm. Groundwater abstraction is utilised for general agricultural use.
Hydrology	Nearest Surface Water ¹		- Tack Lee Brook culverted under the south of the site. - River Roch 600m south, flowing southwest.
	Water Quality Data ¹		- 642m S, River Roch – River Quality C.
	Flooding ¹		- No risk from rivers or sea.
	Surface Water Abstractions ¹		- 3 within 500m: Nearest 59m W at Melba Products Limited. Water is abstracted from four reservoirs fed by spring and surface drainage and utilised for boiler feed and manufacturing.
	Discharge Consent ¹		- 3 within 500m: Nearest 453m NW operated by R A Johnson for release of Sewage discharges (final/treated effluent) to a tributary of the Tack Lee Brook.
	Pollution Incidents ¹		- 3 within 500m: Nearest 404m NW and involved the release of an unknown pollutant to the Tack Lee Brook in October 1995. The incident was recorded as incident severity Category 3 – Minor Incident.

Table 3-1: Summary of environmental setting.

Data Sources: 1 - Envirocheck Report (Appendix A and B); 2 - BGS Sheet 85 1:50,000; 3 - BGS GeoIndex <http://mapapps2.bgs.ac.uk/geoindex/home.html> (Appendix C).

Categories (data sources)		Details
Minerals / Mining	Coal Mining Development High Risk Area ⁴	- Not identified on site.
	Coal Report ⁵	- Not within a surface area that could be affected by past or present underground mining. - No shafts present within 20m of the site. - No record of mine gas emission.
	Surface Extractions ¹	- 1 within 500m; Nearest 456m SW at Smethurst Wood which involved opencast mining of sandstone. Works have now ceased.
	Cheshire Brine Compensation District ⁵	- Not within site area.
Ground Stability ¹ (on-site)	Collapsible Ground	- Very low hazard.
	Compressible Ground	- No hazard.
	Landslide	- Very low hazard.
	Running Sand	- Very low hazard.
	Shrinking / Swelling Clay	- Very low hazard.
	Ground Dissolution	- No hazard.
Landfill sites	Known/Registered ¹	- 1 onsite: 'Bury and Rochdale Old Road' historical landfill registered to Tack Lea Works Limited. Waste stream included inert and industrial waste. Operational between December 1971 and December 1980. - 2 within 250m: - 17m S – 'Lower Elbut Farm'. Waste type not supplied. - 238m S – 'Lower Elbut Farm'. Waste type not supplied.
	Potential ¹	- 1 onsite: Former reservoir in NW of the site potentially infilled by 1992 mapping. - 10 within 250m: - 3 reservoirs located between 7mNW and 232m NW potentially infilled prior to 1999 and 1894 mapping, respectively. - 4 ponds located 94m W and 233m NW potentially infilled between 1910 and 1984 mapping. - Cutting located 16m SE potentially infilled by 1999 mapping. - Well located 232m S potentially infilled by 1894 mapping. - Spring located 75m SE potentially infilled by 1930 mapping.
Radon ¹		- Probability of between 1% and 3% of homes above Action Level. No further action required.
Designated Sites ¹		- Adopted Green Belt onsite. - Area of ancient woodland 66m SE.
Contemporary Trade Directory ¹		- 1 within 100m located on site – Melba Products Ltd (Rubber and Plastic Products – Manufacturers) – entry inactive. .
Fuel Station Entries ¹		- None within 100m.

Table 3-1 (continued): Summary of environmental setting.

Data Sources: 1 - Envirocheck Report (Appendix A and B); 2 - BGS Sheet 85 1:50,000; 4 - The Coal Authority Web Mapping Services (WMS) <http://coal.decc.gov.uk/en/coal/cms/publications/data/map/map.aspx> 5 – Coal Authority Report (Appendix D).

4 SITE RECONNAISSANCE

A site reconnaissance was carried out on 19th January 2016. Hand dug trial holes were not undertaken as accessible areas were hardstood.

An annotated plan with photographs and pertinent features is provided in Appendix E.

Relevant features identified on site are summarised below:

- A concrete yard area is present in the south of the site and was noted to be in poor condition.
- An open manhole covered by plywood was noted in the centre of the concrete yard.
- An electrical substation was observed on the eastern site boundary.
- The main former Works building is of stone construction with more recent extensions constructed of brick and corrugated metal.
- Only small sections of the former buildings were safely accessible due to damage from the fire and subsequent degradation of the building.
- Potential asbestos containing material including pipe lagging and cement bound tiles was noted to be present within the former buildings. This was noted to be in a poor condition.
- The former hydraulic press and production area was accessible and sumps in the concrete floor were noted to contain significant quantities of hydraulic oil. An overturned plastic fuel tank was also present in this area.
- Tack Lee Brook is culverted below the site and is present in an open section adjacent to the west of the site.
- Land to the rear (north) of the building slopes upwards to the former Works reservoirs and is heavily vegetated.
- Evidence of sheet piling was noted on the sloping ground to the north suggesting that ground is being retained.
- Three reservoirs, the central and eastern ones being significantly silted up, were present on the raised ground to the north with the central reservoir being within the current planning boundary.
- Land immediately to the north of the main former Works building was waterlogged indicating that water was draining from the sloped ground to the north to this area.
- A retaining wall was present in an area to the north east of the main former Works building and evidence of a former tank (concrete tank base) was also noted.
- Himalayan Balsam was noted in several areas of the site.

The surrounding area comprises predominately farmland and woodland with Bury and Rochdale Old Road adjacent to the south and a row of terraced residential properties to the east of the site entrance.

5 PRELIMINARY CONCEPTUAL MODEL

5.1 Introduction

The aim of the conceptual model is to provide a preliminary assessment of the likelihood of a pollutant linkage for each potential combination of contaminant, pathway and receptor. A conceptual model can be used to make an informed decision on the contamination risks associated with the site and whether further site investigation work is required.

The Sections below are therefore divided into potential contaminant, potential pathway and potential receptor as described in CLR11⁴. The final Section provides an assessment of the potential pollutant linkages that may still be present on the site if redevelopment were to occur.

5.2 Potential Contaminants

Rubber / Plastic Products Works

The most recent site use (up to 2007) was a Works producing plastic and rubber products for the highways industry.

Typical contaminants associated with rubber/plastic manufacturing include solvents (BTEX and chlorinated solvents), PAHs (anthracene, phenanthrene, benzo(a)pyrene), phenols, amines, petroleum hydrocarbons, sodium hydroxide, zinc and iron compounds, rubber crumb, and sulphate⁵.

A section of the Works building in the west was recorded as previously containing hydraulic presses and an area outside was denoted as a storage area for hydraulic oils. During the site reconnaissance, sumps containing significant quantities of hydraulic oil were also noted in this part of the Works building.

Information on the former processes at the former Plastic Products Works indicates that inks and thinners were used in several areas of the site and were stored in the concrete yard area in the south. Potential contaminants related to the use of inks and thinners are solvents, amines, alcohols and BTEX compounds.

A number of tanks including a diesel tank have also been recorded as present on site associated with the former Works and these may be a source of hydrocarbon contamination.

An electrical substation and old transformer have been recorded in the west of the site associated with the former Works. These are both considered to be a potential source of polychlorinated biphenyls (PCBs) and transistor oils.

Asbestos may have been used within the building as insulation and lagging or as roofing and cladding. Evidence of suspected ACM in the building structures was noted during the site reconnaissance and was noted to be in a poor condition.

As previously reported a major fire was known to have occurred at the site in 2006. It was reported at the time that a number of fire crews were present onsite to fight the blaze. Therefore, there is the potential for contamination associated with fire and firewater. Firewater contamination is related to heavy metals, oil/fuel hydrocarbons, PAHs and fire

⁴ Defra (2004). "Model Procedures for the Management of Land Contamination." R&D Publication CLR 11.

⁵ DoE (1995). "Industry Profile: Chemical works – Rubber Processing Works."

retardants such as Perfluorooctane Sulfonate (PFOS) and therefore these may be present onsite

Bleach Works

The site was recorded as Tack Lea Bleach Works from as early as 1894 mapping. Typical contaminants associated with a bleach works include bleaching agents and dyes such as acids and alkalis, chlorine, and caustic soda.

Other ancillary activities could include coal fired boilers producing large quantities of boiler ash (heavy metals, sulphates and PAHs⁶).

Textile Works

Anecdotally, the Works on site were associated with textile processing and dyeing. Potential contaminants associated with this land use include metals, other inorganic compounds (e.g. cyanides, sodium compounds, sulphide compounds, chloride compounds, mineral acids, alkalis), chlorinated organic solvents, sizing agents, other organic compounds (e.g. formaldehydes, polyvinyl chloride), water repellents (organo silicon, oxazoline), fire/flame retardants (e.g. borax, ammonium phosphate, brominated organic compounds with metals oxides), soaps and detergents⁷.

Made ground onsite

Made ground is likely to be present on the site and may contain demolition rubble from former buildings and ash and clinker (i.e. from hearth and boilers) which was historically often used for site levelling / raising.

A historical landfill is present in the south of the site and a former reservoir has been infilled in the northwest of the site.

Contamination associated with ash and clinker could include heavy metals (such as arsenic and lead), sulphates and PAHs.

The former building structures may also have contained Asbestos Containing Materials (ACMs) which could be present within the made ground following demolition.

If a significant depth of organic / putrescible material is present, hazardous gas (principally carbon dioxide and methane) could also be generated on site.

Landfills / Potentially infilled ground off site

Known landfills and potentially infilled ground has been identified within 250m of the site. These have the potential to generate hazardous gas (principally carbon dioxide and methane).

The potential for migration of hazardous gas can depend upon the age of the feature, volume of material, type of infill material, size of feature distance from the site and intervening geology.

Given the size of the features, the close proximity to the site and the age of infilled (in the last 30 years) there is considered to be a likely source of hazardous gas.

⁶ Defra (2002). "Potential Contaminants for the Assessment of Land." R&D Publication CLR 8.

⁷ Department of the Environment. Industry Profile. Textile Works and Dye Works. 1995

5.3 Potential Pathways

The pathways are split into the migration of soil, water and gas.

Soil

This also includes soil-derived dust / fibres, vapours from the soil and the uptake of contaminants from the soil into flora / vegetables.

Principal potential pathways associated with human health from soil contamination are ingestion, dermal and inhalation. The current UK technical report document⁸ recognises ten such pathways comprising four ingestion, two dermal and four inhalation. These are listed as follows:

- Ingestion of soil
- Ingestion of soil-derived indoor dust
- Ingestion of contaminated vegetables
- Ingestion of soil attached to vegetables
- Dermal contact with soil
- Dermal contact with soil-derived indoor dust
- Inhalation of soil-derived outdoor dust
- Inhalation of soil-derived indoor dust
- Inhalation of vapours outside
- Inhalation of vapours inside

The proposed end-use follows a standard conceptual model of residential. For this land use scenario all ten of the pathways will have to be considered.

Soils may be within direct contact with receptors (e.g. building foundations, services). Soils can also generate dust / fibres which could migrate via windblow to adjacent receptors.

Water

Surface water and groundwater are principal mechanisms for the migration of contaminants. The following pathways are considered in the assessment:

- Surface run-off over impermeable surface.
- Infiltration into the ground, through potentially contaminated material (contamination possibly going into solution).
- Migration through potentially permeable strata and preferential pathways, such as drains, sewers, culverts, faults and mine workings.

The anticipated Till (superficial) is likely to be relatively impermeable and will significantly reduce the migration of potential contaminated waters.

Devensian Till is anticipated in the south of the site at depth, however, given the historical presence of landfilled features in this area, the depth and composition of the made ground is unknown. Given this it is assumed that the ground conditions will be permeable and capable of acting as a pathway for the downward migration of potential contaminants.

The geology comprises Pennine Lower Coal measures Formation and is likely to variably permeable and could therefore act as a pathway for the migration of potential contaminated waters.

Site drainage associated with the former reservoirs and the culverted Tack Lee Brook could also act as preferential pathways to contamination waters.

Gas

⁸ EA (2008). "Updated Technical Background to the CLEA Model." Science Report – SC050021/SR3.

Gas can migrate via the following potential pathways:

- Migration through potentially permeable strata and preferential pathways, such as drains, sewers, culverts, faults and mine workings.
- Migration into buildings (e.g. via services) and accumulation of gases in confined spaces (potentially causing explosion if methane is present).

As discussed above, the geology and preferential pathways may act as pathways for gas migration.

5.4 Potential Receptors

Potential receptors include:

- Human Health: future site residents, future site users, offsite land users.
- Controlled Waters: Tack Lee Brook (onsite), and underlying Secondary A Aquifer.
- Buildings and structures.
- Potable water pipes.
- Flora within future gardens/landscaping.
- Ecological: Ancient woodland 66m SE.

5.5 Preliminary Contamination Conceptual Model

The preliminary contamination conceptual model for land at Tack Lea Works, Bury is illustrated in Table 5-1 below and has identified seven generic potential pollutant linkages.

Each linkage is described along with an assessment of the risk based upon guidance on probabilities and consequences outlined in CIRIA C552⁹.

In order to assess the potential risk for each pollutant linkage, an assessment of the magnitude of the potential consequence (severity) of the risk occurring and the magnitude of the probability (likelihood) of the risk occurring has been considered and classified. This is based on the guidance provided in CIRIA C552 and further details including a risk matrix is provided in Appendix F.

Where LKC identified a low to very low risk either limited intrusive investigation work, a watching brief (during construction work) or no investigation work will be recommended. This will be dependent on the nature of the site and the proposed development.

Where the risk falls into the moderate/low risk, LKC will undertake an assessment to establish what category the pollutant linkage will fall into (i.e. moderate or low risk will be chosen).

Where LKC identifies a moderate or higher risk intrusive work or precautionary remedial measures will be recommended.

It should be noted that there may be risk from short term exposure from contaminated soil to site workers. The Preliminary Contamination Conceptual Model deals with long term exposure to key receptors. Acute risks can be easily mitigated by good environmental management of the site during site works. Standard health and safety precautions (as per HSE guidance¹⁰) should be adopted by all workers involved with site enabling and

⁹ CIRIA (2001). "Contaminated land risk assessment: A guide to good practice". C552.

¹⁰ HSE (1991). "Protection of Workers and the General Public During Development of Contaminated Land" London HMSO.

construction works. Therefore, this receptor is not considered in the contamination conceptual model.

Pollutant Linkage	Pathway	Receptor	Contaminant (source)	Probability	Consequence	Risk	Assessment
PL1	- Dermal contact. - Inhalation of soil, fibres and dust. - Ingestion of soils, dust, vegetables, soil attached to vegetables. - Windblown dust.	- Future residents. - Site users. - Offsite receptors.	- ACM (former buildings, potentially in made ground).	Likely	Severe (ACM)	High	- Likely probability from ACM due to age of former buildings and condition of ACM observed during the site reconnaissance. - Likely probability of heavy metals and PAHs given identified ashy made ground on site and extensive industrial land use. - Likely probability of hydrocarbons due to the presence of tanks at the site and significant contamination sources from historic industrial land use. - Contamination could come into contact with receptors in future soft landscaping / gardens. - Recommendation: Intrusive investigation required.
			- Heavy metals and PAHs (ash made ground).	Likely	Medium	Moderate	
			- Hydrocarbons (fuel tanks).	Likely	Medium	Moderate	
PL2	- Inhalation of vapours. - Migration through permeable strata and preferential pathways.	- Future residents. - Site users.	- Volatile Contaminants (made ground, fuels & solvents from onsite Works).	Likely	Medium	Moderate	- Likely probability as rubber/plastic works, bleach works and textile works formerly present at the site which likely utilised solvents, fuels and other volatiles in the manufacturing processes. - Recommendation: Intrusive investigation required.
PL3	- Inhalation of gas. - Migration through permeable strata and preferential pathways. - Explosion in confined spaces.	- Future residents. - Buildings. - Offsite land users.	- Methane, carbon dioxide. (infilling onsite, landfill on site and potentially infilled features within 250m of the site).	Likely	Severe	High	- Likely probability due to viable sources of gas identified and sensitive nature of development (residential). - Recommendation: Gas monitoring required.
PL4	- Surface Run-off. - Migration through permeable strata and preferential pathways - Perched waters migration.	- Groundwater (Secondary A Aquifer). - Surface water (Tack Lee Brook)	- Mobile contaminants (made ground, solvents, fuels, oils, bleaching agents and dyes from onsite Works)	Likely	Medium	Moderate	- Likely probability as contamination source from historic bleach works, rubber/plastic manufacturing works and textile works at the site. - Tack Lee Brook is culverted below the site and is therefore likely to be impacted from historical industrial land uses onsite. - Recommendation: Intrusive investigation required including both groundwater and surface water sampling.
PL5	- Sulphate attack on concrete.	- Building structure.	- Sulphate (made ground).	Likely	Mild	Moderate / Low	- Likely probability of elevated sulphate in made ground due to extensive former industrial land use onsite which may be in contact with concrete used in future buildings. - Moderate risk assumed at this stage. - Recommendation: Intrusive investigation required as part of PL1.
PL6	- Ingestion of tainted water supply.	- Future site users.	- Organic Contaminants (made ground, tanks).	Likely	Medium	Moderate / Low	- Likely probability as significant contamination and made ground anticipated at pipeline depth (0.75-1.35m). - Risk is considered moderate at this stage due to unknown depth of made ground. - Recommendation: Sampling required if made ground present at pipeline installation depths.
PL7	- Direct Contact (plant uptake).	- Flora.	- Phytotoxic Contaminants (made ground).	Likely	Minor	Low	- Likely probability as contamination considered possible, which may be taken up by flora in soft landscaping / gardens. - Recommendation: Investigation work as part of PL1.

Table 5-1 Preliminary Contamination Conceptual Model.

6 GROUND INVESTIGATION

6.1 Site Investigation Design and Methodology

In order to assess the ground conditions at the site and to investigate the potential pollutant linkages identified in the preliminary contamination conceptual model an intrusive investigation was undertaken.

The investigation was carried out on 15th July 2016 and comprised the following:

- 6no. window sample boreholes drilled to 2.45 and 5.44 metres below ground level (mbgl) (ref. WS101 to WS105).
- 6no. trial pits (using JCB 3CX) excavated to 2.6-3.5mbgl (ref. TP101 to TP106).

The site investigation was undertaken in accessible areas outside of the former Works building and within buildings that were deemed safe to enter for investigation staff and plant. Additional investigation works will be required following demolition of the buildings and chimney on site.

The locations were predominately chosen to target areas of concern as presented on Figure 4. Table 6-1 details the targeted and general coverage (non-targeted) site investigation locations. All site investigation locations are shown in Figure 5.

Site Investigation Locations	Rationale
TP101	Hydraulic oil storage area.
TP102	Historic landfill.
TP103	Historic landfill.
TP104	Hydraulic oil storage area.
TP105	General site coverage.
TP106	Historic landfill / car park.
WS101	Hydraulic oil storage area.
WS102	Visual evidence of contamination during walkover / infilled ground.
WS103	Ink and thinners container.
WS104	Historic landfill / diesel fuel tank.
WS105	General site coverage.
WS106	Electrical sub-station.

Table 6-1: Summary of sampling locations.

The number of site investigation location points corresponds to approximately one location per 30m square centres. This is considered to be a conservative sampling density and is in line with BS10175¹¹ for an 'exploratory investigation'. Further investigation work is anticipated to be required to assess the ground conditions further and to be in line with BS10175¹² for a 'main investigation'.

All profile logs are provided in Appendix G and are in line with BS14688-1¹³ and BS5930¹⁴.

6.2 Well Installations

All of the boreholes were installed with monitoring wells for gas and groundwater monitoring, and groundwater sampling. Monitoring wells were installed in accordance

¹¹ British Standard (2011). "Investigation of Potentially Contaminated Sites – Code of Practice." BS10175:2011.

¹² British Standard (2011). "Investigation of Potentially Contaminated Sites – Code of Practice." BS10175:2011.

¹³ British Standards (2002) Geotechnical investigation and testing – Identification and Classification of Soil. Part 1: Identification and description. BS EN ISO 14688-1:2002.

¹⁴ British Standard (2015). "Code of Practice for Ground Investigations". BS5930:2015.

with BS10175 and CIRIA C665¹⁵ and generally comprised approximately 1m plain pipe over a length of slotted pipe surrounded by pea gravel and sealed at the top with bentonite and concrete.

The response zones for the window sample boreholes were installed along the entire length of the borehole.

Well installation details are provided in Profile Logs in Appendix G.

6.3 Sampling Protocol

6.3.1 Soil Sampling (Contamination)

Standard sampling protocol and preservation of samples was undertaken as described in the EA guidance on site investigation¹⁶.

Soil was collected for onsite testing. A plastic zip bag was half filled with soil allowing a suitably sized headspace. The bag was sealed and stored for at least 20 minutes before being tested for total volatile organic compounds (TVOCs) using a PhoCheck photoionisation detector (PID). Results of the PID readings are presented on the profile logs (Appendix G). The on-site monitoring was carried out in line CIRIA C665¹⁷ to aid in screening samples for volatile analysis.

Soil samples of approximately 500g were recovered in amber jars, amber vials for volatile analysis and plastic tubs. All the samples were labelled and stored in cool boxes prior to being collected by courier at the end of the day for delivery to the Chemtest laboratory in Newmarket for chemical testing. If collection was not possible the same day then samples were stored in the sample storage fridge at the LK Group offices below 4°C. Samples were tracked using appropriate Chain of Custody forms provided by Chemtest.

Many of the contamination tests are UKAS or MCERTS accredited and further details are given in the Certificate of Analysis presented in Appendix H.

¹⁵ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

¹⁶ EA (2000). "Technical Aspects of Site Investigation. Volumes 1 & 2 Text Supplements Research and Development Technical Report." P5-065/Tr.

¹⁷ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

Suites and Contaminants	No. Samples	Location & Depth	Justification
Metals / metalloids, pH, water soluble sulphate, speciated PAHs, SOM and asbestos screen.	7	TP101 0.2 TP103 0.5 TP104 0.5 TP106 0.3 WS101 0.15-0.3 WS102 0.2-0.5 WS105 0.5	A basic suite with a broad selection of contaminants tested on samples across the site where no significant evidence of contamination was identified (with the exception of occasional ash, clinker and coal) and no TVOCs identified from the PID tests.
Metals / metalloids, pH, water soluble sulphate, cyanide suite, phenol, TPHCWG, BTEX, MTBE, speciated PAHs, SOM and asbestos screen.	4	TP102 0.3 TP105 1.0 WS103 2.8 WS106 0.4	Evidence of hydrocarbon contamination (visual / olfactory) identified in or close to TP102 0.2m, WS103 2.8m, WS106 0.4m therefore detailed suite undertaken to confirm contamination risk and extent.
Metals / metalloids, pH, water soluble sulphate, cyanide suite, phenol, TPHCWG, BTEX, MTBE, speciated PAHs, VOCs, SVOCs, SOM and asbestos screen.	1	WS102 1.0	Hydrocarbon contamination identified in WS102 1.0m. Although no significant evidence of VOC/SVOCs, a more detailed suite including volatile contaminants included to confirm the contamination risk.
TPHCWG, BTEX, MTBE and SOM.	3	WS103 3.8 WS104 0.4-1.2 WS106 1.9	WS103, WS104 and WS106 tested to confirm the extent of hydrocarbon contamination observed in nearby locations.
PCB 7 Congeners	1	WS106 0.4m	WS106 was tested for PCBs due to its proximity to onsite electrical substation in the northeast of the site.
Asbestos Identification	1	TP102 0.3	TP102 0.3m was tested for asbestos as visual evidence of fibres was observed.

Table 6-2. Summary of soil sample testing undertaken.

Notes: Metal/metalloids = arsenic, cadmium, chromium, (total and hexavalent), copper, lead, mercury, nickel, selenium, vanadium, zinc and boron; TPHCWG=carbon banded and aromatic/aliphatic split petroleum hydrocarbons; PAH=polycyclic aromatic hydrocarbons, BTEX=benzene, toluene, ethylbenzene and xylenes; MTBE=Methyl tert-butyl ether, VOC=Volatile organic Compounds, SVOC= Semi Volatile Organic Compounds, PCB=polychlorinated biphenols, SOM=Soil Organic Matter.

6.3.2 Water Sampling

To establish the condition of shallow groundwater LKC undertook four groundwater samples.

The groundwater samples were collected a minimum of 1 week after drilling had finished and following well development. Sample collection was undertaken using a disposable bailer. The borehole was purged of all standing water and the sample collected from the recharged water. The sample was collected in glass and plastic bottles and a glass vial. A water meter was used to test the pH, temperature and conductivity before sampling until equilibrium conditions were met, as per BS10175¹⁸ guidelines.

Two surface water samples were collected from the Tack Lee Brook both upstream and downstream for the site in order to give an indication of the impact, if any, the site is having upon the surface water receptor. No midstream sample was possible as the brook is culverted below the site and there are no accessible sampling points.

¹⁸ British Standard (2011). "Investigation of Potentially Contaminated Sites – Code of Practice." BS10175:2011.

All water samples were placed in glass bottles, plastic bottles and septum topped vials and stored in ice packed cool boxes. The samples were sent to Chemtest on the same day for analysis.

Sampling was carried out in accordance with BS5930¹⁹ and BS5667-11²⁰

Table 6-3 shows the groundwater testing undertaken.

Suites and Contaminants	No. Samples	Location	Justification
Metals / metalloids, pH, sulphate, cyanide suite, TPHCWG, BTEX, MTBE, speciated PAHs, phenol and hardness.	1	WS105	Detailed suite undertaken randomly within WS105 across the site to confirm the absence of contamination.
Metals / metalloids, pH, sulphate, cyanide suite, TPHCWG, BTEX, MTBE, speciated PAHs, phenol, VOCs, SVOCs and hardness.	3	WS101 WS102 WS103	Detailed suite undertaken in window samples WS101 to WS103 to confirm the absence of groundwater contamination (no significant contamination identified in the soils within WS101 and WS103).
Metals / metalloids, pH, sulphate, cyanide suite, TPHCWG, BTEX, MTBE, speciated PAHs, phenol, VOCs, SVOCs and hardness.	2	Upstream Downstream	Detailed suite undertaken in upstream and downstream surface water samples taken from the Tack Lee Brook in order to confirm the absence of contamination from the site to the surface water receptor.

Table 6-3. Summary of groundwater sampling tests undertaken.

Notes:

Metal/metalloids=arsenic, cadmium, chromium, (total and hexavalent), copper, lead, mercury, nickel, selenium, vanadium, zinc and boron; TPHCWG=carbon banded and aromatic/aliphatic split petroleum hydrocarbons; PAH=polycyclic aromatic hydrocarbons, BTEX=benzene, toluene, ethylbenzene and xylenes; MTBE=Methyl tert-butyl ether, VOC=volatile organic compounds, SVOC=semi volatile organic compounds, PCB=polychlorinated biphenols.

Many of the tests are UKAS or MCERTS accredited and further details are given in the Certificate of Analysis presented in Appendix J.

6.4 Gas Monitoring

All the installed boreholes were monitoring for gas. A total of six monitoring visits were undertaken over three months.

Monitoring was undertaken using a Geotechnical Instruments GA2000 plus / GA5000 in accordance with the monitoring protocol outlined in CIRIA C665²¹ (flow rate measured first). The monitoring was undertaken over a range of weather conditions (including low and falling barometric pressure and heavy rain) to demonstrate worst-case conditions.

The gas monitoring results are reproduced in full in Appendix K.

¹⁹ British Standard (2015). "Code of Practice for Ground Investigations". BS5930:2015.

²⁰ British Standard (2009). "Water Quality – Sampling. Part 11: Guidance on Sampling of Groundwaters". BS ISO 5667-11:2009.

²¹ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

6.5 Geotechnical Testing

6.5.1 In-situ Onsite Geotechnical Testing

In-situ geotechnical tests were performed in the boreholes to further characterise the sub-soil conditions. The following tests were undertaken:

- Standard Penetration Tests (SPTs) were performed in the window sample boreholes and cable percussion boreholes at approximately 1m intervals, generally within the natural strata.
- Shear Vane tests (giving undrained shear strength) were performed in the window sample boreholes (to a maximum depth of 3mbgl) and trial pits at approximately 1m intervals, within the natural clay strata.

The SPT and shear vane readings are provided within the profile logs (Appendix G).

6.5.2 Laboratory Geotechnical Testing

Soil samples were collected in tubs, and bulk bags and sent to Murray Rix Laboratories / Chemtest for geotechnical testing.

Representative soil samples taken during the site investigation and were selected for chemical and geotechnical testing. Table 6-4 shows the testing undertaken.

Many of the contamination tests are UKAS or MCERTS accredited and further details are given in the Certificate of Analysis presented in Appendix I.

Suites and Contaminants	No. Samples	Location	Justification
Atterberg Limits (plasticity testing)	5	TP101 2.0m WS103 4.5m WS104 3.0m WS105 3.0m WS106 1.8m	A selection of clay samples across the site were tested for Atterberg Limits to assess their shrinkability potential associated with current and proposed trees.

Table 6-4. Summary of geotechnical testing undertaken.

7 GROUND CONDITIONS

7.1 Geology

7.1.1 Generalised Sequence

The ground conditions beneath the site comprised made ground underlain by natural sandy gravelly clay. A summary section of the logs are provided in Plate 7-1, with additional comments below.

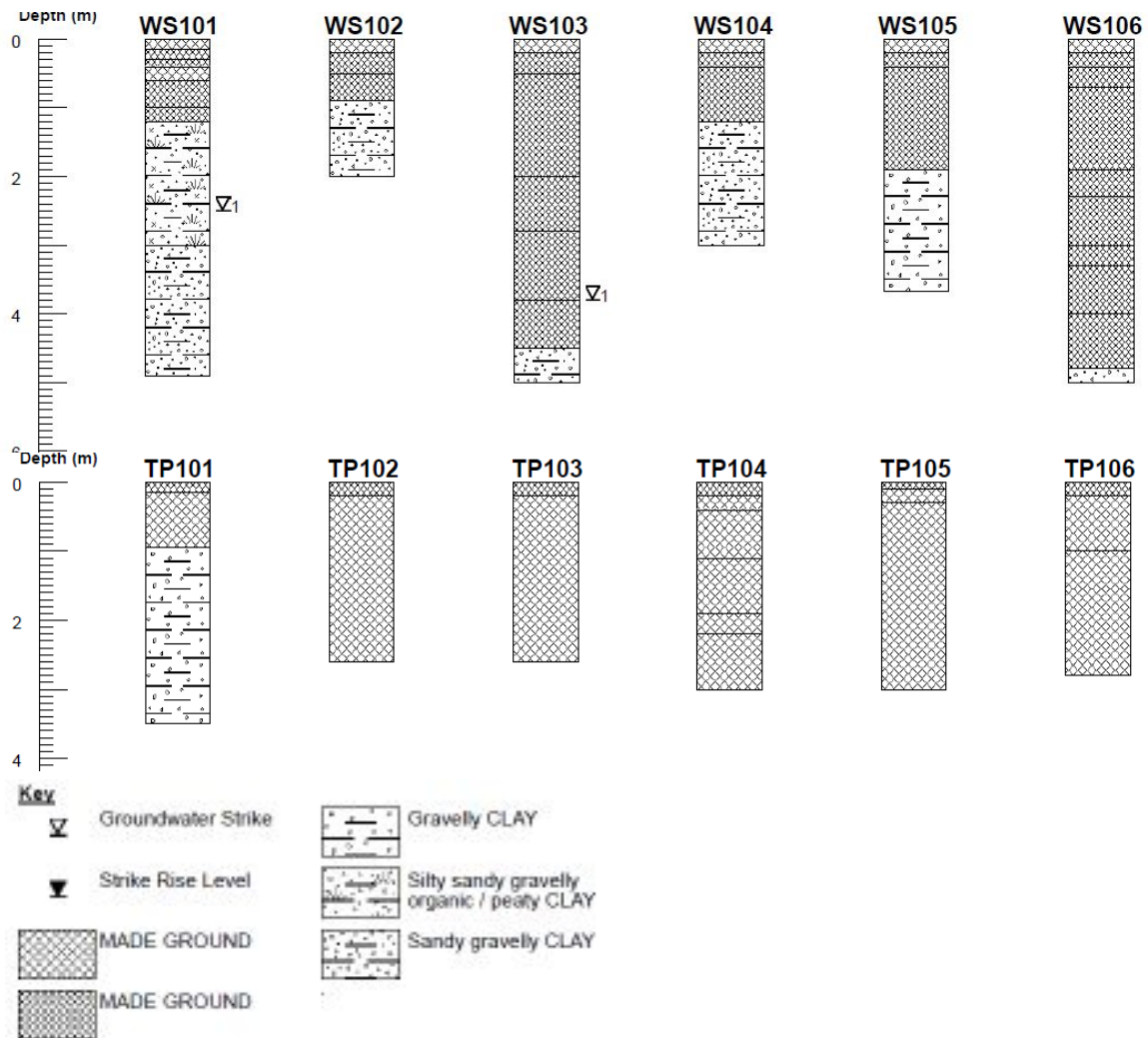


Plate 7-1: Summary of ground conditions.

Additional information on ground conditions:

- The made ground generally consisted on gravelly sandy clay / clayey gravelly sand / clayey gravelly sand with brick, coal, ash and clinker. Made ground was variable across the site with depths between 0.95m and 4.8m identified.
- Visual / olfactory evidence of hydrocarbon identified in TP102 at 0.3-0.6mbgl, WS102 at 0.9-1.5mbgl, WS103 at 2.8m and 3.8mbgl, and WS106 at 0.4-0.7mbgl.
- Visual / olfactory evidence of oil identified in WS102 at 0.5-0.9mbgl.

- No visual / olfactory evidence of hydrocarbons or volatile contaminants in any locations.
- Localised peaty clay was identified within WS101 in the west of the site at 1.2-3.00mbgl.

7.2 Groundwater

7.2.1 Groundwater Levels

Groundwater strikes were recorded during the investigation in trial pits and boreholes. In addition, groundwater monitoring within the borehole wells has been undertaken on three occasions. An oil-water interface probe (approximately 1cm detection limit) was used to detect the presence of free phase hydrocarbons within each borehole.

Results are summarised in Table 7-2.

BH/TP	Water Strike Depths (mbgl)	Well Response Zone (mbgl)	No. of Monitoring Visits	Monitoring Depths (mbgl)			Sample Taken?	Evidence of Contam?
				Min	Max	Base		
WS101	2.5	1.0-3.0 (ALL)	6	1.67	2.24	3.02-3.04	Y	N
WS102	Dry	1.0-2.0 (C)	6	0.46	0.75	1.93-1.95	Y	Y ¹
WS103	3.8	1.0-5.0 (ALL)	6	4.29	4.30	4.92-4.96	Y	N
WS104	Dry	1.0-3.0 (ALL)	6	2.92	Dry	3.02-3.05	N	N
WS105	Dry	1.0-3.5 (ALL)	6	1.69	1.75	3.48-3.52	Y	N
WS106	Dry	1.0-4.5 (MG)	6	Dry	Dry	4.37-4.44	N	N
TP101	Dry	-	-	-	-	-	N	N
TP102	Dry	-	-	-	-	-	N	N
TP103	Dry	-	-	-	-	-	N	N
TP104	Dry	-	-	-	-	-	N	N
TP105	Dry	-	-	-	-	-	N	N
TP106	Dry	-	-	-	-	-	N	N

Table 7-2: Summary of water strike depths within boreholes and trial pits.

Response Zones:

MG=Made Ground; C=Clay; ALL=MG & Natural

Notes:

¹ Evidence of free-phase product (light) detected during visit 2.

7.3 In-situ Testing

7.3.1 Standard Penetration Tests

In-situ standard penetration tests (SPTs) were undertaken, predominantly in the natural ground. The results are summarised in Table 7-3 and provided within the profile logs in Appendix G.

Approximate Depth (mbgl)	SPT 'N' Values					
	WS101	WS102	WS103	WS104	WS105	WS106
0-1	-	-	-	-	-	-
1-2	4 (MG)	15 (C)	9 (MG)	13 (MG/C)	16 (MG)	1 (MG)
2-3	8 (C)	16 (C)	6 (MG)	0 (C)	15 (C)	1 (MG)
3-4	19 (C)	-	2 (MG)	50 (C)	16 (C), 50 (C)	1 (MG)
4-5	18 (C)	-	2 (MG)	-	-	2 (MG)
5-6	-	-	8 (C)	-	-	6 (C)
GW Level	1.67-2.24	0.46-0.75	4.29-4.30	2.92	1.69-1.75	-

Table 7-3: Summary of SPT (N) values.

Notes:

MG=Made Ground; C=Clay.

Groundwater level based on strikes during investigation and monitoring data.

7.4 Laboratory Testing

7.4.1 Atterberg Limits

Representative samples of natural clay were subjected to Atterberg Limits (plasticity) and Moisture Content testing and the results are summarised in Table 7-4.

Table 7-5 also includes the modified plasticity index as detailed in Chapter 4.2-D5 of the NHBC standards (modified plasticity index = plasticity index x % less than 425µm sieve / 100%).

Location	Depth (mbgl)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Class	Passing 425 micron (%)	Modified Plasticity Index (%)
TP101	2.00	19	34	16	18	CL	56	10.08
WS103	4.50	18	32	15	17	CL	37	6.29
WS104	3.00	18	33	16	17	CL	78	13.26
WS105	3.00	16	31	13	18	CL	83	14.94
WS106	1.80	24	30	16	14	CL	77	10.78

Table 7-4: Summary of plasticity index testing.

The modified plasticity index is between 6% and 15%. This characterises the clay as having a low volume change potential.

7.4.2 Sulphate and pH

Water soluble sulphate and pH tests were carried out on soil and groundwater samples. Full results are presented in Appendix H (soils) and Appendix J (groundwater) and summarised in Table 7-5.

Strata	pH		Sulphate	
	Soil	Groundwater	Soil (g/l)	Groundwater (mg/l)
Made Ground	7.9-11.6	7.2-8.1	0.054-0.29	24-430
Natural	7.8-8.1		0.024-0.051	

Table 7-5: Summary of pH and sulphate results.

7.5 Foundation Considerations

Final foundation design will need to be confirmed once loadings of proposed buildings are known and details of ground works (i.e. potential cut and fill exercises) are known. It should also be noted that only accessible areas predominately outside of the former Works building have been investigated and additional post demolition investigation will be required

A preliminary foundation assessment is summarised in Table 7-6.

Location	General Ground conditions	Geotechnical Testing	Allowable Bearing Pressure	Anticipated Foundation Type	Concrete Requirements	Other Considerations
Whole Site	Made Ground to between 0.95m and 4.8mbg. Typically between 2-3m in depth. Soft to firm consistency very low to very high strength sandy gravelly CLAY from 0.9m to 4.8mbgl. Groundwater at 0.46-4.30mbgl typically perched within the made ground.	Clay SPTs N=0-50 MPI 6-15	Further site investigation required to determine allowable bearing pressures for foundation design.	Piling.	DS-1 AC-1	Consideration of effects of trees also needs to be considered. Temporary supports of excavations may be required. This report provides an initial indication of ground conditions only. Further site investigation required post demolition for both geotechnical design and to determine contamination across the remainder of the site, once accessible. Detailed design should be carried out by structural engineer.

Table 7-6: Preliminary Foundation Assessment.

Notes:

SPT=Standard Penetration Test N Values; MPI=Modified Plasticity Index.

Concrete requirements based on BRE Digest 2005²²²² BRE (2005). "Concrete in Aggressive Ground." Special Digest 1.

8 GENERIC RISK ASSESSMENT

8.1 Introduction

Current good practice requires that the findings from a site investigation should be evaluated on a site specific basis, using a risk based approach. Risk assessment involves identification and evaluation of the hazards presented by the concentrations of contaminants measured followed by an evaluation of the risks which are associated with these hazards (CLR11²³). Information gathered from the risk assessment has been collated in the revised contamination conceptual model in Section 5.5.

8.2 Soil Risk Assessment

8.2.1 Methodology

With regards to the soil risk assessment LKC will use the following hierarchy:

- Category 4 Screening Levels (C4SLs).
- LQM Suitable 4 Use Levels (S4ULs).
- ATRISK Soil Screening Values (SSVs) and CL:AIRE Generic Assessment Criteria (GACs).

New C4SLs have recently been published^{24,25}. The recent change to the contaminated land guidance has changed the evaluation of risk from 'minimal' (referred to as Health Criteria values (HCVs))²⁶ used to generate Soil Guideline Values (SGVs) to 'low' (referred to as Lowest Level of Toxicological Concern (LLTCs)). The policy companion document and supporting letter by Defra, dated 3rd September 2014, states that C4SLs '*could be used under the planning regime, as well as within Part 2A*'. Based on these comments LKC considers the justifications and assumptions used to generate 'low' risk are suitable for the planning regime.

Where no C4SLs have been generated LKC will use the LQM S4ULs²⁷. Similar assumptions and land uses to C4SLs have been used. However, toxicological information has been based on 'minimal risk' as per previous guidelines and assumptions^{28,29,30,31}.

If contaminants are not present as C4SLs and S4ULs then LKC will use ATRISK SSVs or CL:AIRE GACs³². These follow the 'minimal' risk principal and more stringent exposure parameters and will be conservative.

LKC consider the main risk drivers for PAHs are benzo(a)pyrene (B(a)P) and naphthalene. This is due to B(a)P possibly being a carcinogen and most toxic of the PAHs^{33,34} and

²³ EA (2004). "Model Procedures for the Management of Land Contamination." R&D Publication CLR 11.

²⁴ Defra (2014). "SP1010: Development of Category 4 Screening Levels and Assessment of Land Affected by Contamination – Policy Companion Document."

²⁵ CL:AIRE (2013). "SP1010: Development of Category 4 Screening Levels and Assessment of Land Affected by Contamination – Final project Report."

²⁶ EA (2008). "Human Health Toxicological Assessment of Contaminants in Soils." Science Report – SC050021/SR2.

²⁷ LQM (2014). "The LQM/CIEH S4ULs for Human Health Risk Assessment."

²⁸ EA (2008). "Updated Technical Background to the CLEA Model." Science Report – SC050021/SR3.

²⁹ EA (2008). "Human Health Toxicological Assessment of Contaminants in Soils." Science Report – SC050021/SR2.

³⁰ EA (2008). "A Review of Body Weight and Height Data used within the Contaminated Land Exposure Assessment Model (CLEA)." Project SC050021/Technical Review 1.

³¹ EA (2009). "Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values." Science report SC050021/SR7.

³² CL:AIRE (2009). "The Soil Generic Assessment Criteria for Human Health Risk Assessment."

³³ EA (2002). "Contaminants in Soils: Collation of Toxicological Data and Intake Values for Humans. Benzo[a]pyrene." R&D Publication TOX2.

³⁴ USEPA (1984). "Health Effects Assessment of Polycyclic Aromatic Hydrocarbons (PAHs). EPA 540/1-86-013."

naphthalene the most volatile and soluble³⁵. The new C4SLs indicate B(a)P as a surrogate marker for carcinogenic PAHs, if it falls within appropriate limits, since the risk from other non-carcinogenic PAHs are considered negligible³⁶. For B(a)P to be used as a surrogate marker it should follow the profile described by the HPA (2008)³⁷ and CL:AIRE (2013). Naphthalene will be treated separately using the LQM S4ULs.

The proposed development is for residential houses with gardens, therefore the assessment criteria for residential with plant uptake has been used.

All criteria have been generated using the CLEA V1.06 model³⁸ based either on 1%, 2.5% and 6% Soil Organic matter (SOM). Results will be compared to the nearest appropriate SOM.

A summary of the generic assessment criteria is provided in Appendix L. ATRISK SSVs and CL:AIRE GACs were not required for this dataset and have not been included.

8.2.2 Soil Results Comparison against Assessment Criteria

Elevated and pertinent results are presented in Table 8-1 below and all analysis sheets are presented in Appendix H.

Contaminant		Units	No. of samples	Elevated Results	Sample Location	Criteria (1%/2.5%/6%)	Source of Criteria
Metals	Arsenic	mg/kg	12	42	TP101 (0.2m)	37 (2.5%)	C4SL
				120	TP105 (0.5m)	37 (6%)	
	Lead			520	TP101 (0.2m)	200 (2.5%)	
				230	TP105 (0.5m)	200 (6%)	
PAHs	Benzo(a)pyrene	mg/kg	11	4.1	TP106 (0.3m)	2.7 (2.5%)	C4SL
	8.9			TP105 (0.5m)			
	Naphthalene			280	WS103 (2.8m)	13 (6%)	S4UL
General	pH	pH	13	Range 7.8 to 11.6			
	SOM	%	13	Range 0.79 to 21			
	Asbestos	-	15	Amosite Fibres / Clumps (1.3% asbestos/dried weight of soil sample) identified in TP102 at 0.3m.			

Table 8-1: Summary of elevated and pertinent analytical results.

Notes:

Only results that exceeded assessment criteria have been shown and results from **all depths** are noted. Results have been compared to the nearest appropriate SOM.

8.2.3 Direct Contact Risk – Pollutant Linkage 1

Elevated PAHs and metals (arsenic and lead) have been identified on site, given the number and location of elevated samples, the contamination is considered to be site wide.

The source of the contamination is expected to the ash, clinker and coal noted in the made ground in addition to localised hydrocarbon hotspots.

At the concentrations identified, the contaminants are considered to pose a potential risk to future site users (residents) in gardens and soft landscaped areas, where made ground may be exposed / in contact with vegetables. The principal pathways are the ingestion pathways (soil, dust and vegetables) and dermal contact.

³⁵ EA (2003). "Review of the Fate and Transport of Selected Contaminants in the Soil Environment." Draft technical report P5-079/TR1.

³⁶ CL:AIRE (2013). "SP1010: Development of Category 4 Screening Levels and Assessment of Land Affected by Contamination – Final project Report."

³⁷ HPA (2010). "HPA Contaminated Land Information Sheet: Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)." Version 3.

³⁸ EA (2008). "CLEA Software (Version 1.05) Handbook." Science Report – SC050021/SR4.

The probability of PAH and metal contamination affecting site users is likely. With a medium consequence, the risk is considered to be moderate and further investigation and remediation is likely to be required.

Asbestos

Asbestos (amosite) was identified in TP102 (0.3m) in the southwestern corner of the site. The asbestos was identified as clumps and free fibres quantified to contain 1.2% asbestos by dried weight of the soil sample. The source of the asbestos is likely to be from landfilling in this area of the site.

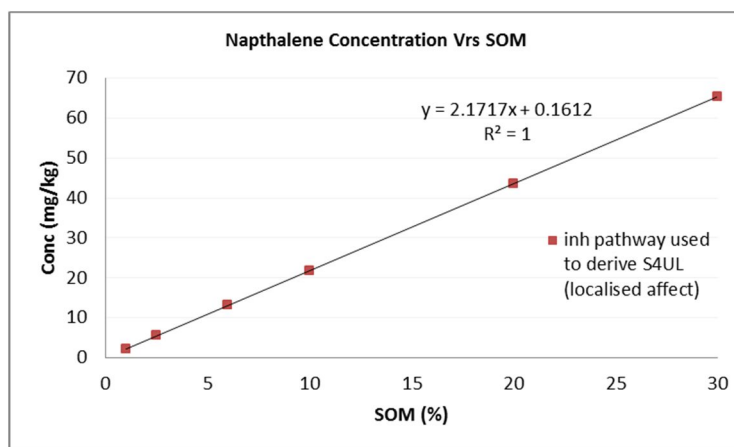
Asbestos may affect site users in soft landscaping and garden areas in localised areas of the site, via the inhalation of fibres. The probability is considered to be likely. With a severe consequence the risk is assumed to be high and localised remediation is recommended.

Additional consideration should also be given to the risk to workers and offsite receptors during groundworks and construction. This is discussed further in Section 7.3.

8.2.4 Inhalation Risk – Pollutant Linkage 2

Naphthalene was elevated in WS103 (2.8 m) at a concentration of 280mg/kg. The SOM value for the sample is 19%.

There is a linear relation ($r^2 = 1$) between Naphthalene and SOM concentrations (see Graph 8-2).



Graph 8-1: Naphthalene vs SOM

The modified assessment criterion for naphthalene is calculated as 41mg/kg, when using the above formula.

Based on the ground conditions encountered and the above risk assessment, there is considered to be a likely probability of volatile contamination posing a risk to site users. Assuming a medium consequence, gives a moderate risk associated with Pollutant Linkage 2 and further investigation and/or remediation is recommended.

8.3 Gas Risk Assessment (Pollutant Linkage 3)

Three gas monitoring visits have been undertaken on the study site. Gas monitoring results in full are presented in Appendix K. Following guidance set out in CIRIA C665³⁹

³⁹ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

and BS8485⁴⁰ peak methane and steady carbon dioxide concentrations have been used in the gas risk assessment. In addition, and as per guidance, flow rates were measured first.

All gas concentrations, flow, pressure and groundwater levels are shown on Table 8-2.

Boreholes	Visit	CH ₄ (%v/v)	CO ₂ (%v/v)	O ₂ (%v/v)	H ₂ S (ppm)	CO (ppm)	Flow (l/h)	Groundwater (mbgl)	Range Pressure (mb)
WS101	1	2.0	6.3	8.2	0.0	9.0	<0.1	2.14	999
	2	<0.1	5.9	9.7	0.0	8.0	<0.1	1.67	988
	3	<0.1	6.9	11.5	1.0	8.0	<0.1	2.24	1000
	4	<0.1	6.3	9.9	1.0	4.0	-0.1	2.20	1006
	5	<0.1	6.5	9.0	1.0	5.0	<0.1	2.20	994
	6	<0.1	6.6	8.5	1.0	3.0	<0.1	2.14	989
WS102	1	<0.1	0.8	18.7	0.0	4.0	<0.1	0.46	998
	2	1.1	2.4	15.7	1.0	23.0	-0.2	0.62	988
	3	0.8	2.0	17.8	1.0	10.0	8.0	0.75	1000
	4	1.5	2.1	17.9	1.0	6.0	<0.1	0.58	1006
	5	0.2	1.6	18.4	1.0	7.0	<0.1	0.51	993
	6	<0.1	2.0	18.9	1.0	2.0	<0.1	0.51	988
WS103	1	<0.1	1.1	18.5	0.0	6.0	<0.1	4.30	999
	2	<0.1	1.5	18.9	1.0	5.0	<0.1	4.29	990
	3	<0.1	4.4	18.7	1.0	7.0	<0.1	4.29	1000
	4	<0.1	1.5	18.6	1.0	9.0	<0.1	4.29	1007
	5	<0.1	1.7	17.7	1.0	6.0	<0.1	4.30	995
	6	<0.1	2.0	17.9	1.0	2.0	<0.1	4.29	990
WS104	1	<0.1	2.7	15.7	0.0	5.0	<0.1	2.96	999
	2	<0.1	0.3	11.9	1.0	2.0	0.1	2.92	991
	3	<0.1	4.4	13.4	0.0	3.0	<0.1	Dry	999
	4	<0.1	2.2	17.1	1.0	5.0	-0.1	2.94	1008
	5	<0.1	1.8	16.6	1.0	6.0	-0.1	2.93	996
	6	<0.1	8.2	9.7	1.0	4.0	<0.1	2.92	991
WS105	1	<0.1	<0.1	20.8	0.0	10.0	<0.1	1.71	999
	2	<0.1	0.1	20.9	1.0	4.0	<0.1	1.69	991
	3	0.1	0.1	20.5	0.0	1.0	0.1	1.75	1000
	4	<0.1	0.1	20.4	1.0	4.0	<0.1	1.69	1008
	5	<0.1	0.1	19.6	1.0	5.0	0.1	1.69	996
	6	<0.1	0.2	20.1	1.0	4.0	<0.1	1.69	991
WS106	1	<0.1	<0.1	20.6	0.0	5.0	<0.1	Dry	999
	2	<0.1	<0.1	21.1	0.0	1.0	<0.1	Dry	990
	3	<0.1	<0.1	20.5	0.0	1.0	<0.1	Dry	1000
	4	<0.1	0.1	20.5	1.0	2.0	-0.1	Dry	1009
	5	<0.1	<0.1	19.7	1.0	1.0	<0.1	Dry	996
	6	<0.1	3.4	15.6	1.0	0.0	-0.1	Dry	992

Table 8-2: Summary of gas monitoring.

Notes:

If concentrations / flow are zero then equipment detection limits are assumed.

Table shows peak concentrations of CH₄, O₂, H₂S, CO and steady concentrations of CO₂.

Bold where CO₂ exceeds 5% and CH₄ exceeds 1%.

Gas Screening Value

In accordance with CIRIA C665⁴¹, a Gas Screening Value (GSV) may be calculated. Assuming worst-case scenario maximum gas concentrations and flow for each borehole have been used to calculate the GSV. The GSV can be used to determine the characteristic situation (CS).

⁴⁰ BSI (2015). "Code of Practice for the Characterisation and Remediation from Ground Gas in Affected Developments." BS8485:2015.

⁴¹ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

Table 8-3 shows the maximum GSV for each borehole and the appropriate characteristic situation (based on GSV only). An overall site assessment (WS101-WS106) has also been included (worst case values across the site).

Boreholes	Max GSV (l/hr)	CS / TL
WS101	0.0069	CS1 / Green
WS102	0.192	CS2 / Amber 1
WS103	0.0044	CS1 / Green
WS104	0.0082	CS1 / Green
WS105	0.0002	CS1 / Green
WS106	0.0034	CS1 / Green
WS101-106	0.16 (CH ₄) / 0.656 (CO ₂)	CS2 / Amber 1

Table 8-3: Summary of worst-case Gas Screening Values (GSV).

Notes:

CS – Characteristic Situation; TL= Traffic Light.

In addition, in accordance with CIRIA C665⁴², if carbon dioxide and methane are recorded above 5%v/v and 1%v/v respectively, you should consider upgrading the characteristic situation from CS1 to CS2.

Based on the maximum GSV for the whole site and due to the number of visits with relatively high carbon dioxide (>5%) and methane (>1%). LKC considered that the site should be treated as CS2. The likely source of the hazardous gas recorded is the former onsite landfilled material.

The gas can potentially migrate into buildings, accumulate in confined spaces and cause explosions (methane) and asphyxiation. At this stage, LKC consider the probability of carbon dioxide and methane affecting site users as likely. Assuming a severe consequence, there is a high risk and gas protection measures are required.

Detectable levels of carbon monoxide (maximum concentration of 23ppm) were also recorded during the gas monitoring. The Health and Safety Executive workplace exposure limits for carbon monoxide are 200ppm for short term exposure limit (STEL) based on a 15 minute reference period and 30ppm for a long term exposure limit (LTEL) based on an 8 hour reference period. As the maximum recorded concentrations at the site are below the LTEL for carbon monoxide the risk from carbon monoxide is considered to be low. Gas protection measures required for carbon dioxide and methane will further reduce the risk from carbon monoxide.

8.4 Controlled Water Assessment (Pollutant Linkage 4)

LKC considers Tack Lee Brook as the primary receptor as it is culverted below the site.

The following hierarchy of assessment criteria have been used in the assessment:

- River Basin District Standards⁴³ and updated Water Framework Directive⁴⁴ groundwater Maximum Threshold Values (TV) or Groundwater Protection Values / General Quality of Groundwater Body (GPV) and Annual Average / Maximum Allowable Concentration Environmental Quality Standards (AA-MAC-EQS). Other criteria will be used from these documents if the above standards are not available for a contaminant.
- Surface Water Abstraction Directive (SWAD)⁴⁵ based on A2 treatment (TPH only).

⁴² CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665.

⁴³ Defra (2010). "The River Basin Districts Typology, Standards and Groundwater Threshold Values". Water Framework Directive (England and Wales) Directions 2010.

⁴⁴ Defra (2015). "Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015".

⁴⁵ Surface Water Directive (EC 75/440/EEC); Water Supply (Water Quality) Regulations 1989, as modified.

- Older Environment Agency Values for UK Drinking Water Standard (UKDWS) and freshwater Environmental Quality Standards⁴⁶ (EQS).

The SWAD criteria are considered appropriate for TPH and would be more realistic criteria than UKDWS. For example the UKDWS for hydrocarbons (dissolved/emulsified) is 10µg/l, whereas it would be 200µg/l using SWAD for normal physical/chemical treatment (A2 treatment). This standard has been repealed in 2007⁴⁷, but values have not been replaced currently in the Water Framework Directive. A recent document by the EA on risk from petroleum hydrocarbons in groundwater⁴⁸ has not derived EQS values for emulsified hydrocarbons but state that it must not form distinctive films or produce harmful effect to fish. It is understood that the EA are working on providing guideline values for individual carbon bands. Until this has occurred LKC considers the use of SWAD to be still acceptable for TPH for surface waters.

The risk from List 2 compound (EC Dangerous Substance Directive 76/464/EEC) in a freshwater ecosystem is governed by the hardness of the water. Where applicable the hardness was taken into account for these contaminants.

Elevated contaminants are presented in Table 8-4 below and all analysis sheets are presented in Appendix J.

Contaminant		Units	No. of samples	Elevate d Result	Location	Assessment Criteria	Source of Criteria
Metals	Mercury	µg/l	4	1.1	WS102	0.75	GPV (2010)
			2	0.58	Downstream	0.07	WFD EQS (2015)
	Copper	µg/l	2	1.4	Upstream	1.0	EQS Freshwater
				2.0	Downstream		
TPH	TPH	µg/l	44	2,500	WS102	200	SWAD
				1,400	WS103		
Gener al	pH	pH	4	Range 7.2 to 8.1			
	Hardness	mg/l CaCO ₃	4	230 to 1,400			

Table 8-4: Summary of elevated groundwater results.

Notes:

EQS (2001) and AA / MAC-EQS (2010) = surface water criteria.

Max TV (2010) – Impact of groundwater on surface water.

UKDWS (2001) and GPV (2010) = Groundwater criteria (potable supply).

TPH result based on SWAD value, Individual fractions also compared to this value to identify distribution of hydrocarbon contamination.

Elevated results have been identified in groundwater samples from window sample boreholes WS102 and WS103, located in the centre and west of the site.

Elevated levels of TPH coincide with evidence of visual / olfactory contamination noted within the logs, and during the second monitoring visit for WS102 where evidence of free product was noted. The source of the contamination in WS102 is likely to be associated with the hydraulic presses previously located in this area of the former Works. Visual evidence of significant contamination was also noted in this area during the site reconnaissance.

It is considered likely that the groundwater at the site is perched within the made ground and is therefore unlikely to directly impact the underlying aquifer within the bedrock at

⁴⁶ EA (2002). "Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part IIA of the Environment Protection Act 1990."

⁴⁷ DWI (2008). "The 2009 Periodic Review of Prices – Guidance on Drinking Water Quality Requirements."

⁴⁸ EA (2009). "Petroleum Hydrocarbons in Groundwater: Supplementary Guidance for Hydrological Risk Assessment."

depth. This should be confirmed by further investigation to confirm the condition of the deeper groundwater at the site.

Significant thicknesses of superficial clay were identified in a majority of the window sample boreholes and this may reduce any sub-surface migration to the controlled waters receptors. However, due to the degree of infilling at the site pathways may exist to the culverted surface water on site in more permeable fill.

In addition, there was evidence of drainage and infrastructure relating to the former reservoirs at the site. These also may represent pathways for contaminated water to the Tack Lee Brook.

Samples taken from the Tack Lee Brook, both upstream and downstream of the site, were screened against the environmental quality standards for surface water receptors. Both samples highlighted exceedances in copper, with a greater concentration recorded in the downstream sample. An exceedance of mercury was identified within the sample taken from downstream. This indicates that the site could be negatively impacting the surface water receptor. However, it is recommended that further testing is undertaken to confirm the extent of impact the site is having upon the surface water quality.

Based on the above, LKC considers the probability of contaminants on site affecting the Tack Lee Brook as likely. Given the medium consequence, a moderate risk is anticipated (Pollutant Linkage 4).

8.5 Additional Risk Assessment

8.5.1 Concrete (Pollutant Linkage 5)

As discussed in Section 4.7, sulphate resistant concrete will not be required at the site. The site was classified as DS-1 AC-1.

Based on the above, the probability of sulphate concentrations affecting buildings is unlikely. Given the consequence is considered to be mild, the risk (pollutant linkage 5) is anticipated to be low risk and no remediation is required. This should be confirmed with the structural engineer.

8.5.2 Potable Water Supply (Pollutant Linkage 6)

Soil results were compared to United Utilities (UU) guidelines for the selection of potable water pipes in land potentially affected by contamination⁴⁹. Only contaminants of concern, based on the preliminary conceptual model and ground conditions encountered, were analysed.

The following elevated contaminants were identified:

- Elevated TPH in made ground across the site.
- Elevated TVOCs (inc. naphthalene) in made ground across the site.

It is likely that barrier pipe will be required across the site subject to the depth and location of the water pipes and in consultation with UU.

Once details of the pipeline location and depths are known a UU Risk Assessment should be undertaken.

⁴⁹ UU(2011). "United Utilities Water Supplementary Guidance for the Selection of Water Pipes in Land Potentially Affected by Contamination."

At this stage, the probability of organic contaminants affecting potable water pipes is likely. Given the consequence is considered to be moderate, the risk (pollutant linkage 5) is anticipated to be moderate risk and remediation (i.e. barrier pipe is likely to be required (subject to further risk assessment)).

8.5.3 Phytotoxicity (*Pollutant Linkage 7*)

Soil results were compared to phytotoxic guideline values as outlined in BS3882⁵⁰.

No elevated contaminants were identified therefore the probability of phytotoxic contaminants affecting vegetation is considered to be unlikely. With a minor consequence, the risk (pollutant linkage 7) is anticipated to be very low.

⁵⁰ BS (2015). "Specifications for Topsoil and Requirements for Use." BS3882:2015.

8.6 Revised Contamination Conceptual Model

The preliminary contamination conceptual model (Table 5-1) has been revised following the risk assessments undertaken in Sections 8.1-8.5. The revised contamination conceptual model follows the same methodology and guidance used in the preliminary contamination conceptual model. The risk matrix is provided in Appendix F.

The revised contamination conceptual model is presented in Table 8-5.

Where there is a moderate/low risk is identified, an assessment will be undertaken to establish what category the pollutant linkage will fall into.

Where LKC identifies a moderate or higher risk, remediation or further investigation work is recommended. Where a low risk is identified, some form of remediation may be required depending on the pollutant linkage, the type and concentration of contaminants present and the proposed development. Where a very low risk is identified no specific remediation is required.

Further details of the remedial proposals and a remedial option appraisal are given in Section 7.

Pollutant Linkage	Pathway	Receptor	Contaminant	Probability	Consequence	Risk	Assessment
PL1	- Dermal contact. - Inhalation of soil, fibres and dust. - Ingestion of soils, dust, vegetables, soil attached to vegetables. - Windblown dust.	- Future residents. - Site users. - Offsite receptors.	ACM: - Amosite	Likely	Severe	High	- ACM (amosite) identified in made ground in the southwest of the site which could pose a risk to future site residents / users via the inhalation of fibres. No asbestos was identified elsewhere during the site investigation, however, given the heritage of the site and areas currently without investigation there is considered to be a likely possibility of asbestos present within the made ground at the site. - Recommendation: Further investigation and remediation required. Likely to include a 1m environmental cover system in gardens / soft landscaping areas.
			Heavy metals: - Arsenic and lead. PAHs: - PAHs.	Likely	Medium	Moderate	- Elevated metals (arsenic and lead) and PAHs identified in the made ground across the site which could come into contact with site users in soft landscaping areas. - Recommendation: Remediation required. Likely to include an environmental cover system in gardens / soft landscaping areas.
			Hydrocarbons - Fuel tanks.	Likely	Medium	Moderate	- Potential risk remains as no investigation possible in the north of the site. - Recommendation: Further post demolition investigation required.
PL2	- Inhalation of vapours. - Migration through permeable strata and preferential pathways.	- Future residents. - Site users.	Volatile Contaminants: - Naphthalene.	Likely	Medium	Moderate	- Elevated naphthalene was recorded in WS103 in the centre of the site. - Potential risk remains as no investigation possible in the north of the site. - Recommendation: Further post demolition investigation and remediation required.
PL3	- Inhalation of gas. - Migration through permeable strata and preferential pathways. - Explosion in confined spaces (methane only).	- Future residents. - Buildings. - Offsite land users.	- Carbon dioxide	Likely	Severe	High	- Elevated carbon dioxide identified (max. 8.2%v/v) and GSV classified as CS2. - Recommendation: Gas protection measures required.
			- Methane	Likely	Severe	High	- Elevated methane concentrations identified (max. 2.0%v/v) and elevated flow (max. 8.0/hr). - Recommendation: Gas protection measures required.

Table 8-5: Revised Contamination Conceptual Model.

PL4	- Surface Run-off. - Migration through permeable strata and preferential pathways - Perched waters migration.	- Groundwater (Secondary A Aquifer) - Surface water (Tack Lee Brook).	Mobile contaminants: - Mercury and TPH.	Likely	Medium	Moderate	- Elevated concentrations of mercury and TPHs were identified within the groundwater perched within the made ground. There is considered to be potential for the migration of contamination at the site to the Tack Lee Brook which is culverted below the site and the Secondary A Aquifer located at depth. - Elevated mercury and copper identified within samples taken from the Tack Lee Brook downstream of the site. - Further investigation to determine the sites impact on deeper groundwater and the surface water feature is required. - Recommendation: Further post demolition investigation and potential remediation required.
PL5	- Sulphate attack on concrete.	- Building structure.	- Sulphate.	Unlikely	Mild	Very Low	- No elevated sulphate identified in soils or groundwater. - Recommendation: No remediation required.
PL6	- Ingestion of tainted water supply.	- Future site users (via potable water).	Organic Contaminants: - Naphthalene, metals, TPH.	Likely	Medium	Moderate	- Likely probability as elevated organic contaminants identified which could permeate water pipes and contaminate water supply. - Recommendation: UU risk assessment undertaken. Barrier piping likely to be required.
PL7	- Direct Contact (plant uptake).	- Flora.	Phytotoxic Contaminants: - Zinc, copper, nickel.	Unlikely	Minor	Very Low	- No elevated contaminants identified. - Recommendation: No remediation required.

Table 8-5 (continued): Revised Contamination Conceptual Model.

9 CONCLUSIONS

9.1 Geotechnical

Given the depth of made ground present at the site, piling is considered to be the most suitable foundation solution.

No sulphate resistant concrete is required (DS-1 AC-1).

However, further site investigation is required post demolition for both geotechnical design and to determine ground conditions across the remainder of the site, once accessible.

Further advice on foundation design should be sought from a structural engineer.

9.2 Contamination Assessment

A revised contamination conceptual model has been produced by LKC which is summarised in Table 9-1 below (more detailed model provided in Section 8). Where a moderate / low risk was identified, the assumed risk at this stage has been shown.

	Pollutant Linkage	Risk	Recommendations
1	Contaminants posing a risk to site users via dermal contact, ingestion and inhalation (of soil, dust, fibres and vegetables).	High (ACM)	ACM (amosite) identified in made ground. Recommendations: Further investigation and remediation required in garden areas.
		Moderate (metals, PAHs)	Elevated arsenic, lead and PAHs identified across the site. Recommendations: Remediation required in garden areas.
		Moderate	No elevated petroleum hydrocarbons identified. Further investigation required in the northern half of the site. Recommendations: No remediation required at present. Further investigation and potential remediation required.
2	Volatile contaminants posing a risk to site users via the inhalation of vapours.	Moderate	Volatile contamination identified in the centre of the site. Recommendations: Further investigation and assessment required.
3	Gas posing a risk to buildings and site users via the migration of gas into building causing explosion and asphyxiation.	High	GSV based on gas monitoring results places the site within a CIRIA C665 CS2 at this stage. Recommendations: Further gas monitoring required.
4	Mobile contamination posing a risk to controlled waters via the migration through permeable strata.	Moderate	Elevated mercury and TPH identified within groundwater. Elevated mercury and copper identified within sample from Tack Lee Brook downstream of site. Recommendations: Further investigation and potential remediation required
5	Sulphate posing a risk to building via direct contact (sulphate attack).	Moderate	No elevated sulphate identified in soils or groundwater. Recommendation: No remediation required.
6	Organic contaminants posing a risk to water pipes.	Moderate	Organic contamination identified at potable pipe depth of 0.75-1.35mbgl. Recommendations: UU risk assessment to be completed. The site will likely require barrier piping.
7	Phytotoxic metals posing a risk to flora via root uptake.	Very Low	No phytotoxic metals above generic criteria. Recommendations: No remediation required.

Table 9-1: Summary Risk Table.

Remedial recommendations are presented in Section 7.

10 REMEDIAL RECOMMENDATIONS

The recommendations provided below are considered appropriate for the site based on the site investigation work undertaken. LKC should stress that no remediation, enabling works or designing works should take place until Regulatory approval has been obtained.

A more detailed Remediation Strategy should be produced following the completion of further post demolition investigation.

10.1 Remediation and Validation

Table 10-1 details the further works and remedial recommendations / requirements. The table shows work required post-demolition of building(s), pre-construction (i.e. during earthworks) and during / post construction.

PL	Remediation Requirements	Validation Requirements
1, 2, 5, 6, 7	<u>Post-demolition Investigation</u> This is recommended to confirm ground conditions below the current buildings and allow delineation of areas of concern. This should allow a more targeted remediation strategy to be completed. This work will also provide more geotechnical information for foundation design.	N/A (Investigation Report will be provided with an updated Remediation Strategy).
N/A	<u>Grubbing Out of In-Ground Structures</u> It is recommended that in-ground structures are grubbed out as part of the groundworks. In-ground structures expected in west of the site associated with the former docks and buildings.	N/A (for geotechnical purposes only).
1 & 2	<u>Earthworks Site Inspections</u> A watching brief (daily / weekly) should be maintained during earthworks to confirm the ground conditions and identify any unusual ground conditions. Should any unusual ground conditions be encountered, work should stop and samples be collected for chemical analysis. Depending on the outcome of the chemical analysis further remediation may be required.	Log of work undertaken including photographs. Details of any sampling undertaken and validation of any potential additional remedial work (TBC).
2	<u>Vapour Risk</u> Volatile contamination identified has been localised to date. The level of remediation will be dependent on the findings of further post demolition investigation. For example, if further volatile contamination is identified then site wide remediation such as vapour barriers in buildings may be required. If only localised volatile contamination is identified then delineation and removal of contaminated soils may be a more feasible option. Further assessment should be undertaken to confirm the risk to site users and the requirement for remediation.	TBC (dependant on findings of additional work).
1 and 7	<u>Environmental Cover System</u> As made ground is relatively deep, it is unlikely to be viable to remove the contaminated soils. Therefore an environmental cover system is recommended. The environmental cover system should be as follows: Private Gardens: 600mm thick environmental cover system comprising: Either 100mm physical break layer (MOT type 1 material, 20-30mm, minimal fines) and at least 500mm comprising clean inert fill and sufficient topsoil for a growing medium. Or geotextile membrane and at least 600mm comprising	Measuring depth of environmental cover system using a staff and providing photographic evidence. Photographic evidence of the granular physical break or geotextile layer will also be collected. Chemical validation of imported

	clean inert fill and sufficient topsoil for a growing medium. Shared Landscaping: 300mm thick environmental cover system comprising: Either 100mm physical break layer (MOT type 1 material, 20-30mm, minimal fines) and at least 200mm comprising clean inert fill and sufficient topsoil for a growing medium. Or geotextile membrane and at least 300mm comprising clean inert fill and sufficient topsoil for a growing medium. The subsoil layer can be replaced by additional topsoil. A diagram of a typical environmental cover system is shown in Appendix M.	soils: See Table 10-2.
3	Gas Protection Measures In line with CS2 as per UK guidance^{51,52}. This is likely to / should include: • Ventilated sub-floor void. • Carbon dioxide resistant membrane installed as per manufacturer's instructions. • Well-constructed reinforced suspended, raft or cast in situ ground slab. • Minimum penetration of ground slab by services. • All joints and penetrations to be sealed. Depending on the type of building and foundation design the protection measures can vary. The gas protection measures will be detailed and approved with the Local Authority once the foundation design has been confirmed.	Supply and review of foundation designs. Photographic evidence of sub-floor void, ventilation and suitably sealed gas membrane. Validation of gas protection measures should be in line with CIRIA 735⁵³
4	Controlled Waters The results of initial groundwater and surface water sampling indicate that there may be a risk to controlled waters from leachable metals and TPH. Further surface water samples from Tack Lee Brook are recommended to confirm the risk. Further site investigation, including sinking of 2no. deeper boreholes to determine the sites impact upon the groundwater regime below the site, is recommended. Consultation with the Environment Agency is recommended with regards to further investigation and risk assessment works. Approval should also be sought for any proposed remediation works. Remediation may comprise removal of the contamination source e.g contaminated made ground or in-situ treatment of the dissolved phase contamination plumes.	TBC (dependant on findings of additional work).
5	Sulphate Resistant Concrete Sulphate Resistant Concrete in line with DS-1 AC-1 recommended.	N/A
6	Potable Water Pipes It is recommended that a Water Pipeline Assessment is undertaken once the location and depth of potable water pipes are known. It is likely that barrier pipe will be required.	Delivery Notes of Pipe Material. Photographs of the Installed Pipe.

Table 10-1: Further work, remediation and validation requirements

Notes: See Table 6-1 for pollutant linkage (PL) details.

⁵¹ CIRIA (2007). "Assessing Risks Posed by Hazardous Ground Gases to Buildings." CIRIA C665

⁵² BSI (2015). "Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for new buildings." BS8485:2015.

⁵³ CIRIA (2014). "Good Practice on the Testing and Verification of Protection Systems for Building Against Hazardous Ground Gas". CIRIA C735.

10.1.1 Validation of Imported Subsoil / Topsoil

Chemical validation of all imported soils to be used on site in gardens and soft landscaping areas should be undertaken. Imported soils should be accompanied by a certificate of analysis and source details.

A summary of the required imported material sampling requirements are presented in Table 10-2. Ideally, the material should be sampled at source to prevent double handling if soil fails, with confirmatory sampling undertaken on importation to site. However, where this is not possible then material imported should be segregated based on source and soil type. Validation samples should be taken prior to placement in gardens to ensure suitability for use.

Material Type	Source	Suite of Analysis	Sampling Rate
Topsoil	Greenfield	Suite A	1 sample per 50m ³ (minimum of 3 samples per source)
	Brownfield / Unknown	Suite B	
Subsoil	Brownfield / Unknown	Suite B	1 sample per 150m ³ (minimum of 3 samples per source)
	First Generation i.e. quarried sand (subsoil) or stone (break layer)	No testing is required. Certification of material provenance is required.	
Physical Stone Break Layer	Recycled Stone (6F2 / screened)	Suite B	1 sample per 500m ³ (minimum of 3 samples per source)

Table 10-2: Sampling requirements for imported soils.

Notes:

Suite A - Heavy metals, pH, water soluble sulphate, speciated PAH, soil organic matter and asbestos screen.

Suite B - Heavy metals, pH, water soluble sulphate, speciated PAH, phenol, total and free cyanide, soil organic matter, asbestos screen, banded petroleum hydrocarbons (TPH CWG), BTEX, MTBE.

Any soil with visual or olfactory evidence of hydrocarbons should be rejected.

In addition, it should be ensured that the matrix of the topsoil is suitable as a growing medium and no undesirable material is present (in line with BS3882⁵⁴). LKC advice this information is provided by the supplier before material is imported onto site.

Imported material to be used in gardens will be compared against residential with plant uptake criteria (as used in the contamination risk assessment (Section 8-1)). Appropriate remedial target criteria are presented in Appendix L.

10.2 OTHER CONSIDERATIONS

10.2.1 Further Investigation

LKC consider the risk to controlled waters to be moderate based on the evidence of contamination identified to date. Further post demolition investigation will be required to assess the ground conditions and any potential contamination below the former Works buildings.

In addition, to allow a better understanding of the hydrogeological regime below the site it is also recommended to undertake further investigation of the deeper groundwater. This should comprise up to 2no. cable percussive boreholes across the site to up to 15mbgl.

⁵⁴ BS (2015). "Specifications for Topsoil and Requirements for use." BS3882:2015.

Due to the variability of the superficial deposits and deeper made ground in some areas additional investigation using cable percussive methods will also allow the investigation of deeper strata and identification of bedrock.

10.2.2 Health and Safety Considerations

In working with, removing or treating any contaminating material it is important that any potential risks associated with the actual site works are mitigated by good environmental management of the site during the remedial phases. Standard health and safety precautions (as per HSE guidance⁵⁵) should be adopted by all workers involved with site enabling and construction works.

10.2.3 Asbestos Management Strategy

Due to the presence of asbestos containing material, it is recommended that additional precautions are taken during site clearance, earthworks and construction in the area of concern. The presence of asbestos in the made ground at the site presents a potential risk of generation of airborne fibres if this material is disturbed, such as for excavations to construct new foundations.

This risk can be managed by careful procedures and site monitoring to reduce the risk of airborne fibres, and it is recommended that an appropriate 'Asbestos Management Strategy' is developed and adopted for all intrusive ground works which disturb the made ground in the area of concern. This should be carried out in line with CIRIA C733⁵⁶.

This may include asbestos awareness training for all site staff, provision of suitable personal and respiratory protective equipment and air monitoring.

With regards to cement bound asbestos, this can be handpicked, doubled bagged and disposed of appropriately to a licenced landfill. Guidance on removing asbestos cement is described in HSE (2012)⁵⁷.

If ACM is identified in soil arisings then soil should be placed directly into covered skips and disposed of at a suitable licenced landfill, after further testing to quantify the extent of asbestos contamination of the soils. It should be considered that blue asbestos is notifiable and must be removed by a licenced contractor.

10.2.4 Piling in Contaminated Land

It is understood that the building will be piled into the bedrock. This may provide a preferential pathway for contaminants to the Secondary B Aquifer. Once the method of piling has been determined, good practice for the drilling of piles on contaminated sites should be adhered to, such as guidance provided by the Environment Agency⁵⁸.

10.2.5 Unexpected Contamination

The relevant contractors should be briefed that during development works at the site should any unusual ground conditions and / or visual or olfactory evidence of contamination (including asbestos containing material) be encountered at the site, LKC and the Local Authority should be informed and further assessment of the material may be required.

⁵⁵ HSE (1991). "Protection of Workers and the General Public During Development of Contaminated Land" London HMSO.

⁵⁶ CIRIA (2014). "Asbestos in Soil and Made Ground: A Guide to Understanding and Managing Risks". C733.

⁵⁷ HSE (2012). "Removing Asbestos Cement (AC) Debris." A11 Asbestos Essential – Non-licenced Tasks.

⁵⁸ Environment Agency (2001) Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention.

10.3 Detailed Remediation Strategy

Given the nature and extent of contamination identified on the site, a detailed Remediation Strategy is likely to be required for the site. This should be undertaken following the post demolition investigation and any further assessment of groundwater conditions. The detailed Remediation Strategy should be issued to the relevant regulatory bodies for approval prior to commencing remediation works.

10.4 Remediation, Verification and Site Completion Report

Once planning approval is successful it is strongly recommended that the proposals detailed within this report are approved in writing by the Local Authority prior to works starting on site.

It is recommended that any remediation carried out on the site is validated by a third party and suitable documentary evidence provided in a Site Completion Report, such as photographs, consignment documents and analytical results. This is likely to include:

- Further site investigation to better characterise the site.
- Details of delineation work for identified contamination.
- Validation of remediation for impacted groundwater, if required.
- Validation of gas protection measures, if required.
- Validation of capping depths in garden and soft landscaping areas.
- Verification testing of all imported soil for garden and soft landscaping areas.
- Information on the installation of protective pipes and / or sterile trenches.

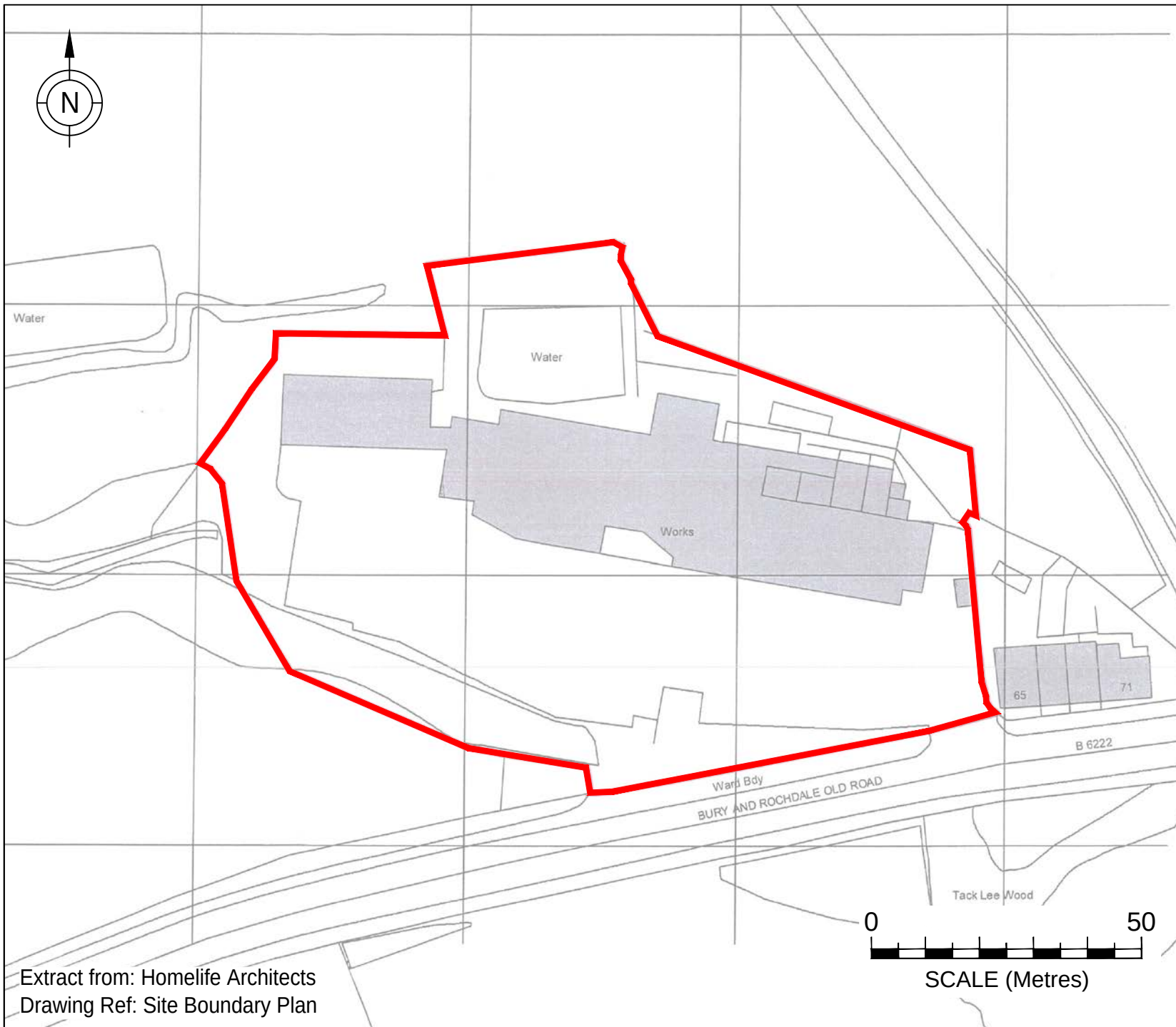
The Site Completion Report will assist the Local Authority in the discharge of any future relevant planning conditions and will also be of use to solicitors acting on behalf of any prospective conveyancer who may have concerns over the former use of the site.

FIGURES



Figure 1: Site Location Plan, Tack Lea Works, Bury

Drawn: July 2016 Scale: 1:25,000 @ A4 (see scale bar)



KEY



Site Boundary

Sampling Locations and features annotated by LK Consult Ltd are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.



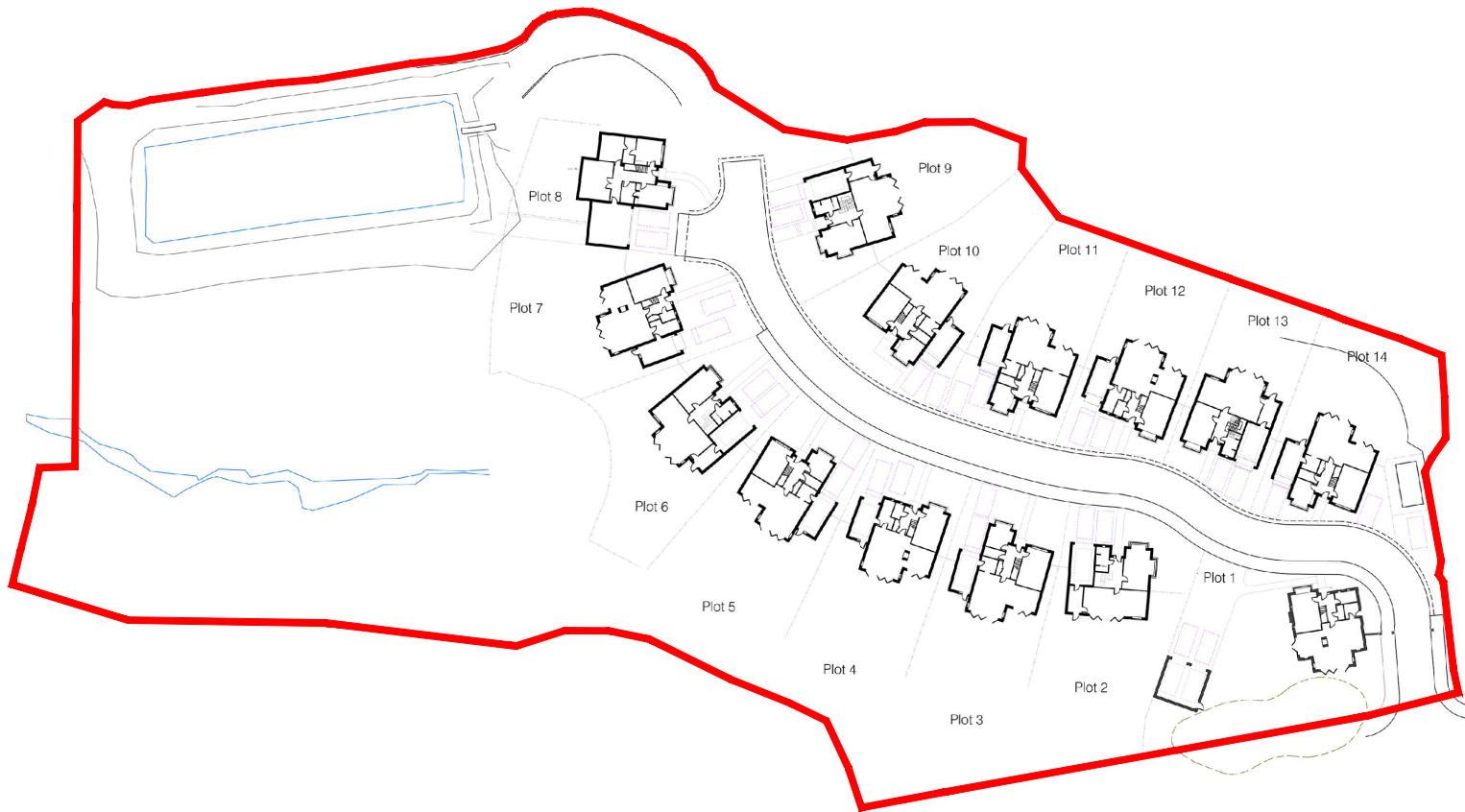
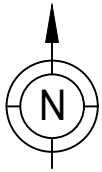
Client: Hall & Co Developments Ltd

Site: Tack Lea Works, Bury

Title: Site Layout Plan

Job No.: LKC 16 1018	Scale (See Scale Bar): 1:1000 @ A4	Figure: 2	Revision:
Drawn By: AC	Checked By: CB	Drawn: Aug 2022	

Extract from: Homelife Architects
Drawing Ref: Site Boundary Plan



KEY



Sampling Locations and features annotated by LK Consult Ltd are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.



Client:
Hall & Co Developments Ltd

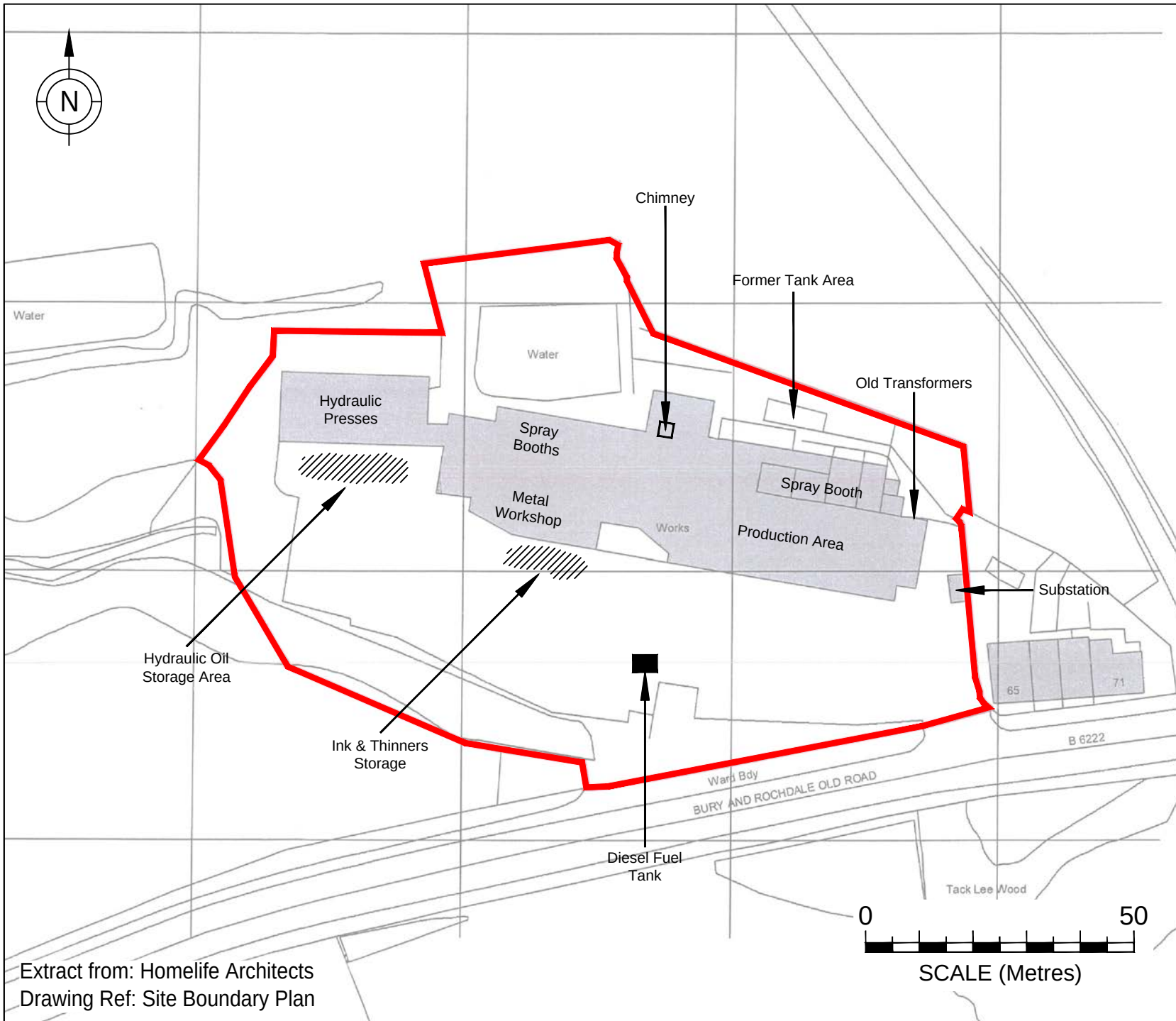
Site:
Tack Lea Works, Bury

Title:
Proposed Layout Plan

Job No.:	LKC 16 1018	Scale (See Scale Bar):	See Scale Bar	Figure:	3	Revision:	
Drawn By:	AC	Checked By:	CB	Drawn:	Aug 2022		

Extract from: Cartwright & Gross Ltd
Drawing Ref: Proposed Site Plan, No.779/200, Rev:D (23/11/2018)





KEY



Sampling Locations and features annotated by LK Consult Ltd are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.



Client:
Hall & Co Developments Ltd

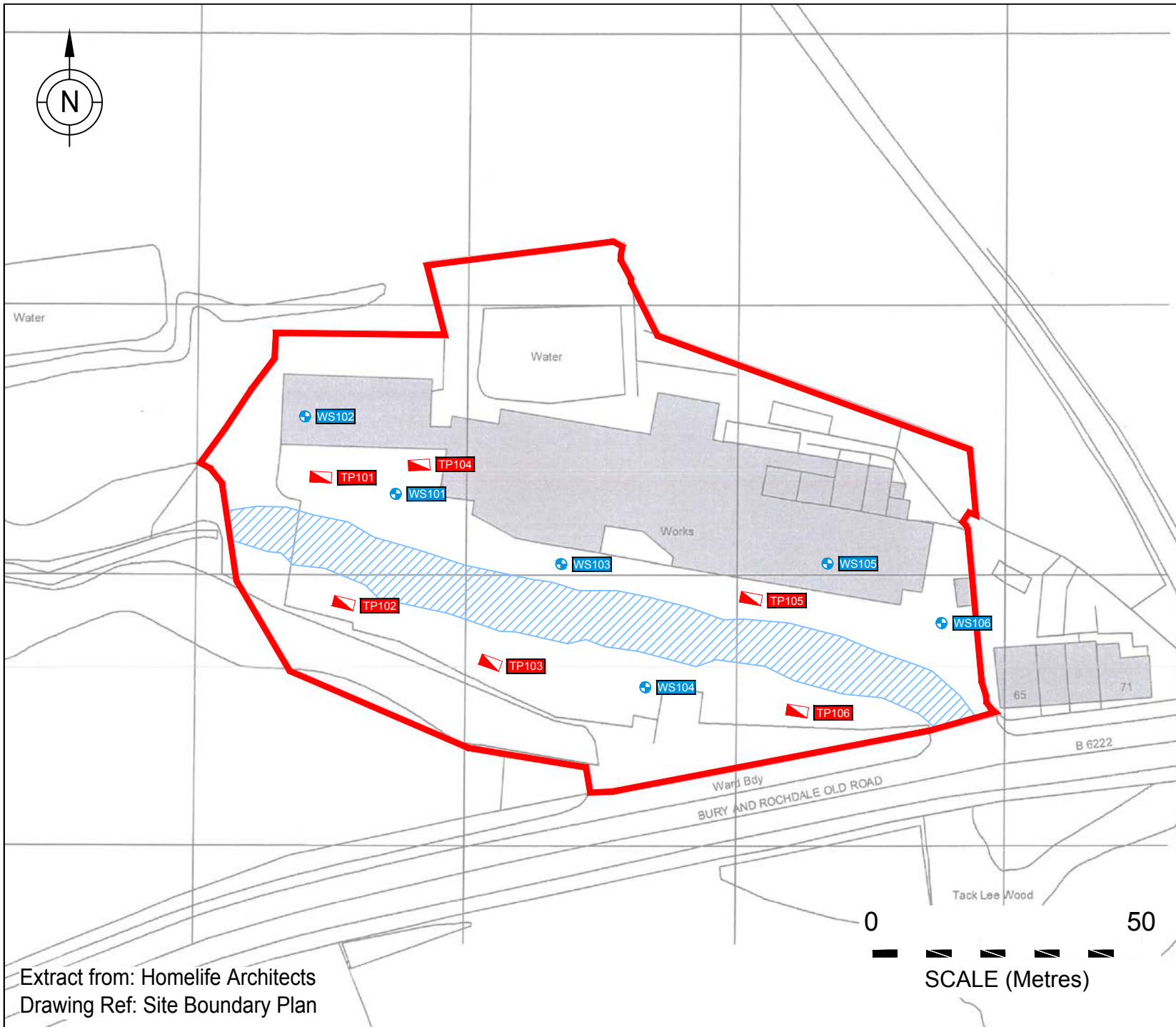
Site:
Tack Lea Works, Bury

Title:
Former Works Site Features

Job No.: LKC 16 1018	Scale (See Scale Bar): 1:1000 @ A4	Figure: 4	Revision:
Drawn By: AC	Checked By: CB	Drawn: Aug 2022	

Extract from: Homelife Architects
Drawing Ref: Site Boundary Plan

SCALE (Metres)



KEY

-  Site Boundary
-  Window Sample Borehole (WS)
-  Trial Pit (TP)
-  Approximate Location of On-site Culvert

Sampling Locations and features annotated by LK Consult Ltd are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor. Where this drawing includes information provided to LK Consult Ltd by others, LK Consult Ltd gives no warranty, representation or assurance as to the accuracy of such information.



Client: Hall & Co Developments Ltd

Site: Tack Lea Works, Bury

Title: Sampling Location Plan

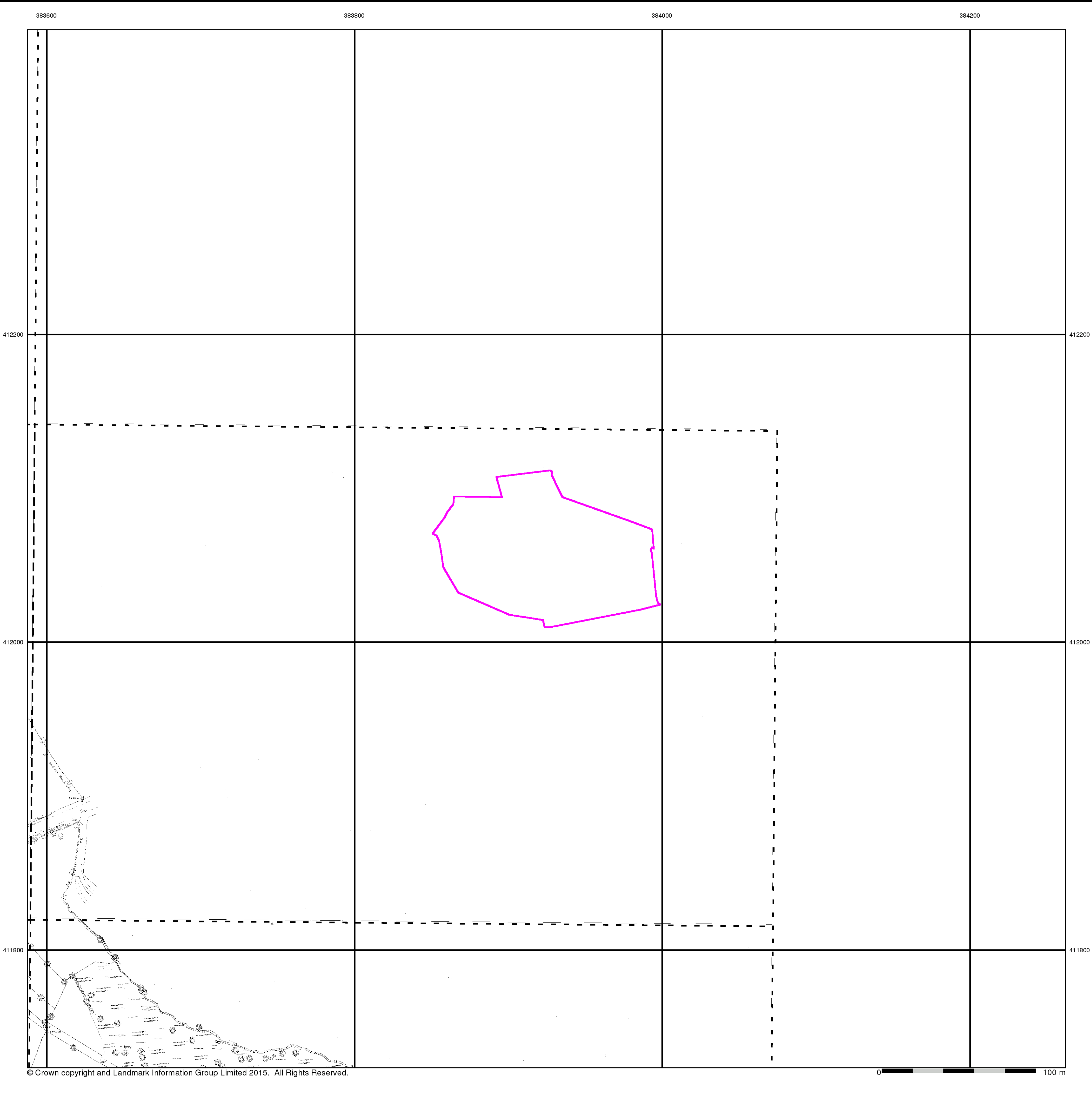
Job No.: LKC 16 1018	Scale (See Scale Bar): 1:1000 @ A4	Figure: 5	Revision:
Drawn By: AC	Checked By: CB	Drawn: Aug 2022	

Extract from: Homelife Architects
Drawing Ref: Site Boundary Plan

SCALE (Metres)

APPENDIX A

HISTORICAL MAPS



LK
CONSULT LIMITED
Lancashire And Furness
Published 1891
Source map scale - 1:500

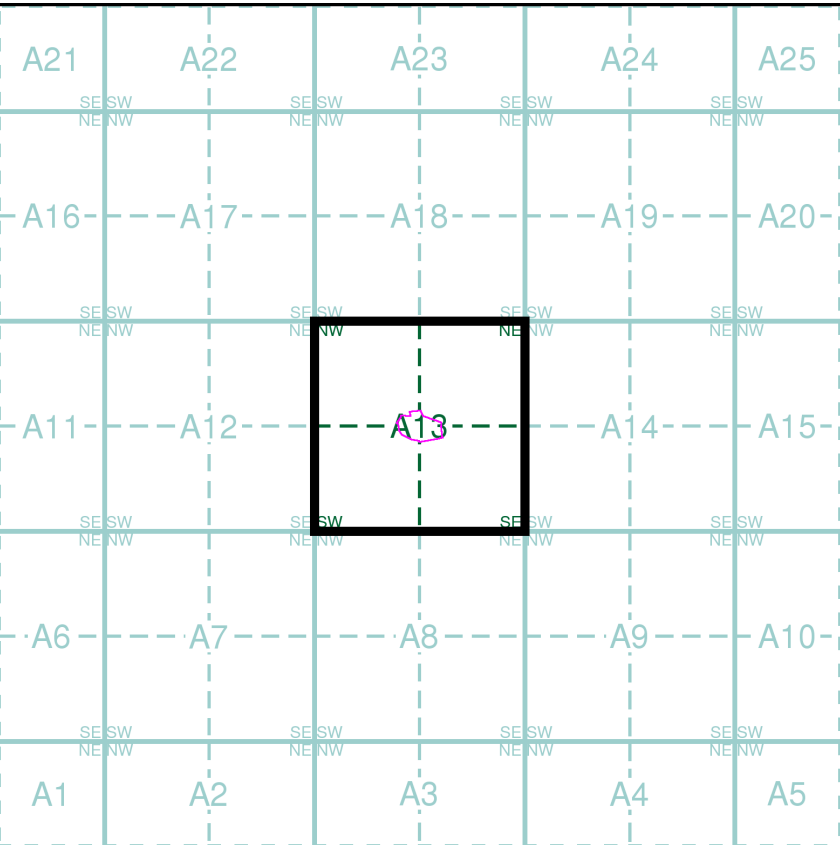
The 1:500 scale Ordnance Survey mapping was introduced in 1855 as a replacement for the 1:528 scale and to compliment the 1:2500 scale that had been implemented in 1853. By 1895, the 1:500 scale covered most towns over a population of about 4000 at the time of survey, although very few towns were mapped more than once at this scale, and none have been since 1910. The 1:500 scale gives particular emphasis to such features as lamp posts, man holes, arched passages and minor building projections. Also often featured are divisions between tenements, interior ground floor layouts of public buildings, and on earlier plans, the functions of the various parts of larger industrial premises are also indicated. Content of the plans does vary however, from one town to the next in terms of, for example, the completeness of railway tracks and the coverage of public buildings.

Please note: Due to the partial coverage of Historical Town Plans, it is possible that not all segments within an order will contain mapping. Only the segments that have Town Plan coverage will be generated.

Map Name(s) and Date(s)

088_06_008	
1891	
1:500	
088_06_013	088_06_014
1891	1891
1:500	1:500
088_06_018	088_06_019
1891	1891
1:500	1:500

Historical Town Plan - Segment A13



Order Details

Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 0

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

	Gravel Pit		Sand Pit		Other Pits
	Quarry		Shingle		Orchard
	Osiers		Reeds		Marsh
	Mixed Wood		Deciduous		Brushwood
	Fir		Furze		Rough Pasture
	Arrow denotes flow of water		Trigonometrical Station		
	Site of Antiquities		Bench Mark		
	Pump, Guide Post, Signal Post		Well, Spring, Boundary Post		
	285 Surface Level				
	Sketched Contour		Instrumental Contour		
	Main Roads		Minor Roads		
	Sunken Road		Raised Road		
	Road over Railway		Railway over River		
	Railway over Road		Level Crossing		
	Road over River or Canal		Road over Stream		
	Road over Stream				
	County Boundary (Geographical)				
	County & Civil Parish Boundary				
	Administrative County & Civil Parish Boundary				
	County Borough Boundary (England)				
	County Burgh Boundary (Scotland)				
	Rural District Boundary				
	Civil Parish Boundary				

Ordnance Survey Plan 1:10,000

	Chalk Pit, Clay Pit or Quarry		Gravel Pit
	Sand Pit		Disused Pit or Quarry
	Refuse or Slag Heap		Lake, Loch or Pond
	Dunes		Boulders
	Coniferous Trees		Non-Coniferous Trees
	Orchard		Scrub
	Bracken		Heath
	Marsh		Reeds
	Building		Glasshouse
	Sloping Masonry		Pylon
	Cutting		Embankment
	Road Under		Road Over
	Level Crossing		Foot Bridge
	Standard Gauge Multiple Track		Standard Gauge Single Track
	Siding, Tramway or Mineral Line		Narrow Gauge
	Geographical County		Administrative County, County Borough or County of City
	Municipal Borough, Urban or Rural District, Burgh or District Council		Borough, Burgh or County Constituency
	Civil Parish		
	Boundary Post or Stone		Police Station
	Church		Post Office
	Club House		Public Convenience
	Fire Engine Station		Public House
	Foot Bridge		Signal Box
	Fountain		Spring
	Guide Post		Telephone Call Box
	Mile Post		Telephone Call Post
	Mile Stone		Well

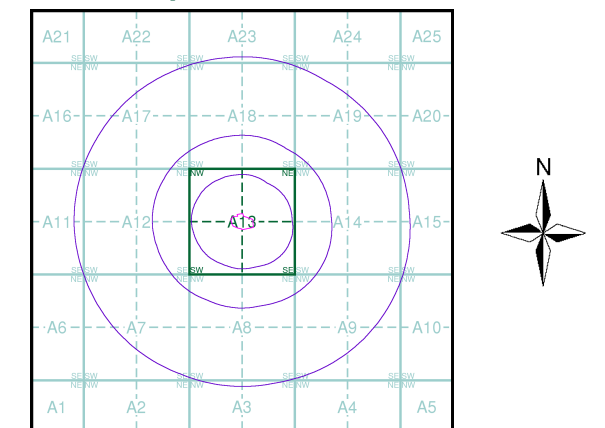
1:10,000 Raster Mapping

	Gravel Pit		Refuse tip or slag heap
	Rock		Rock (scattered)
	Boulders		Boulders (scattered)
	Shingle		Mud
	Sand		Sand Pit
	Slopes		Top of cliff
	General detail		Underground detail
	Overhead detail		Narrow gauge railway
	Multi-track railway		Single track railway
	County boundary (England only)		Civil, parish or community boundary
	District, Unitary, Metropolitan, London Borough boundary		Constituency boundary
	Area of wooded vegetation		Non-coniferous trees
	Non-coniferous trees (scattered)		Coniferous trees
	Coniferous trees (scattered)		Positioned tree
	Orchard		Coppice or Osiers
	Rough Grassland		Heath
	Scrub		Marsh, Salt Marsh or Reeds
	Water feature		Flow arrows
	Mean high water (springs)		Mean low water (springs)
	Telephone line (where shown)		Electricity transmission line (with poles)
	Bench mark (where shown)		Triangulation station
	Point feature (e.g. Guide Post or Mile Stone)		Pylon, flare stack or lighting tower
	Site of (antiquity)		Glasshouse
	General Building		Important Building

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Lancashire And Furness	1:10,560	1851	3
Lancashire And Furness	1:10,560	1894	4
Lancashire And Furness	1:10,560	1910 - 1911	5
Lancashire And Furness	1:10,560	1931 - 1932	6
Lancashire And Furness	1:10,560	1938 - 1939	7
Ordnance Survey Plan	1:10,000	1956	8
Ordnance Survey Plan	1:10,000	1967 - 1968	9
Manchester	1:25,000	1975	10
Ordnance Survey Plan	1:10,000	1977	11
Ordnance Survey Plan	1:10,000	1984 - 1988	12
Ordnance Survey Plan	1:10,000	1993	13
10K Raster Mapping	1:10,000	1999	14
Historical Aerial Photography	1:10,000	2000	15
10K Raster Mapping	1:10,000	2006	16
VectorMap Local	1:10,000	2016	17

Historical Map - Slice A



Order Details

Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

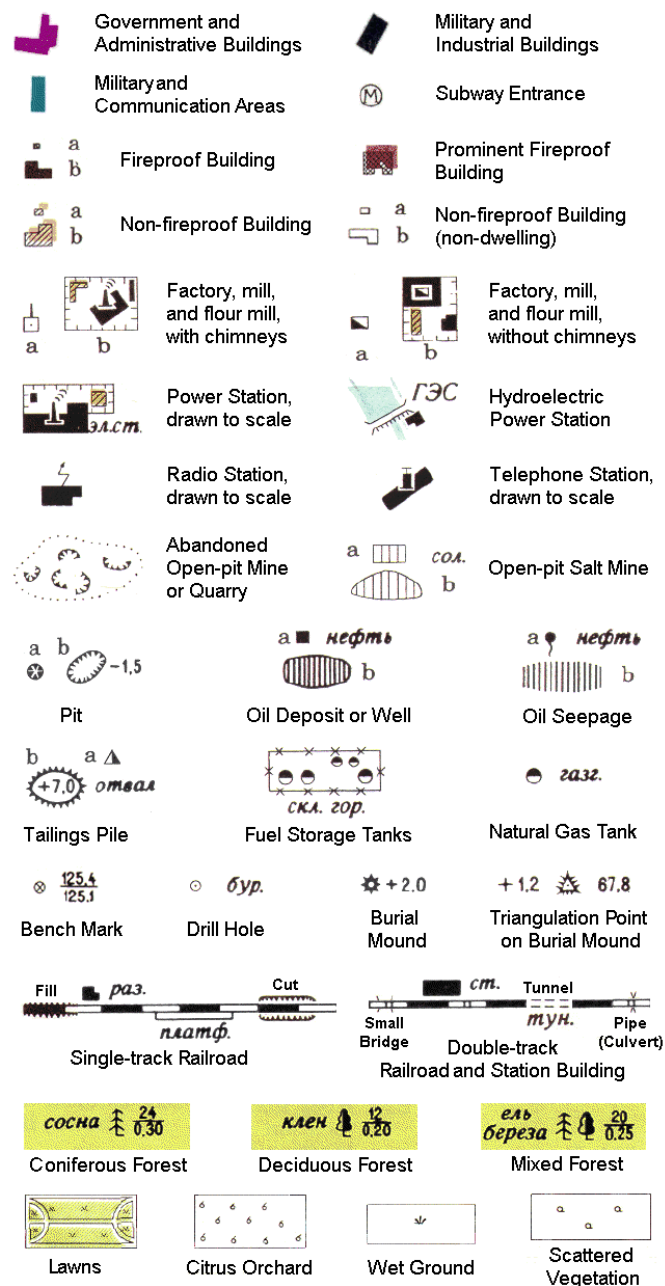
Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Russian Military Mapping Legends

1:5,000 and 1:10,000 mapping

a. Not drawn to scale b. Drawn to scale



243.8 Values for prominent elevations

186.0 Numbers for spot elevations, depth soundings, contour lines, etc.

0.2 Velocity of the current, width of river bed, depth of river

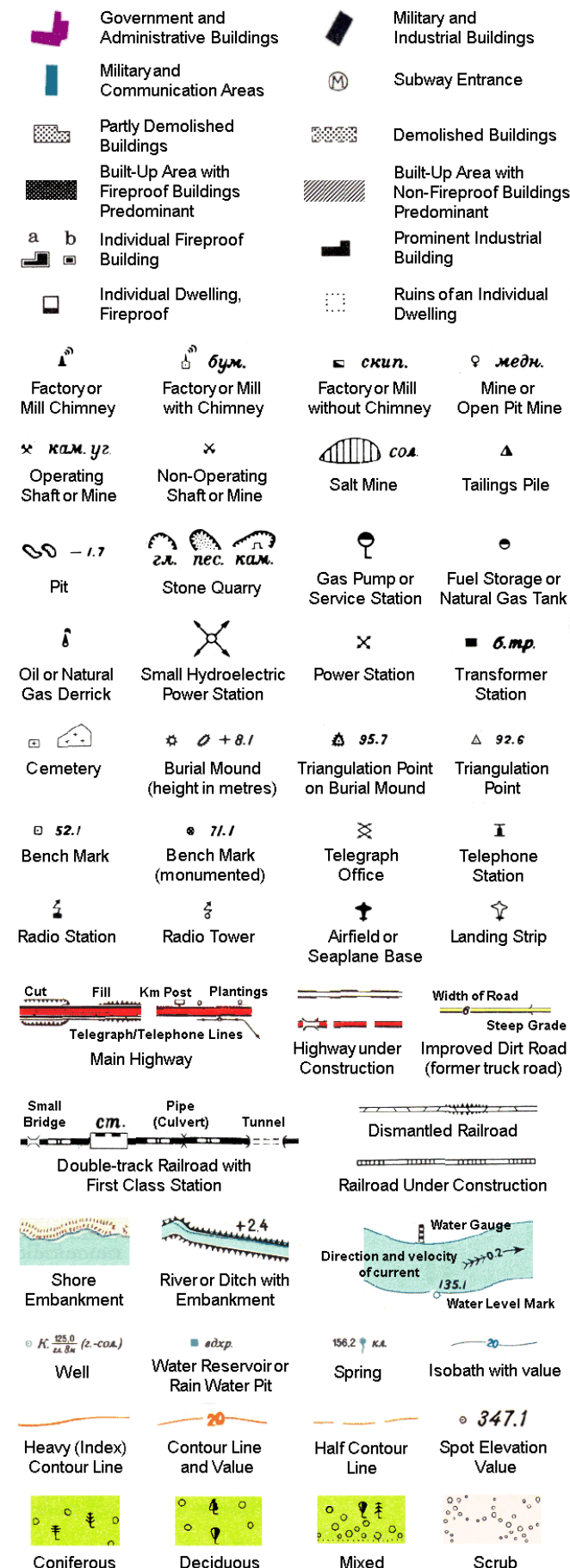
180/12 Fractional terms: length and capacity of bridges; depth of fords and condition of the river bottom; height of forest and the diameter of trees

Russian Alphabet (For reference and phonetic interpretation of map text)

А а (A)	З з (Z)	П п (P)	Ч ч (CH)
Б б (B)	И и (I)	Р р (R)	Ш ш (SH)
В в (V)	Й й (Y)	С с (S)	Щ щ (SHCH)
Г г (G)	К к (K)	Т т (T)	Ъ (-)
Д д (D)	Л л (L)	У у (U)	Ы (Y)
Е е (E)	М м (M)	Ф ф (F)	Ь (')
Ё ё (YO)	Н н (N)	Х х (KH)	Э э (E)
Ж ж (ZH)	О о (O)	Ц ц (TS)	Ю ю (YU or IU)
			Я я (YA or IA)

1:25,000 mapping

a. Not drawn to scale b. Drawn to scale

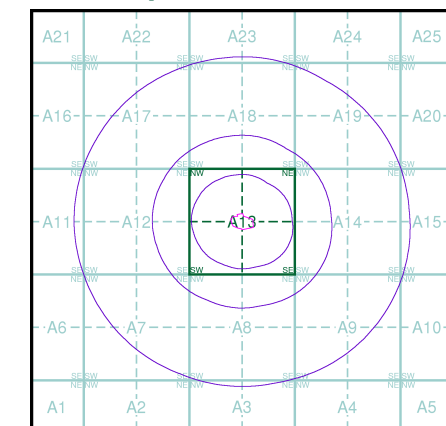


Key to Numbers on Mapping



Mapping Type	Scale	Date	Pg
Lancashire And Furness	1:10,560	1851	3
Lancashire And Furness	1:10,560	1894	4
Lancashire And Furness	1:10,560	1910 - 1911	5
Lancashire And Furness	1:10,560	1931 - 1932	6
Lancashire And Furness	1:10,560	1938 - 1939	7
Ordnance Survey Plan	1:10,000	1956	8
Ordnance Survey Plan	1:10,000	1967 - 1968	9
Manchester	1:25,000	1975	10
Ordnance Survey Plan	1:10,000	1977	11
Ordnance Survey Plan	1:10,000	1984 - 1988	12
Ordnance Survey Plan	1:10,000	1993	13
10K Raster Mapping	1:10,000	1999	14
Historical Aerial Photography	1:10,000	2000	15
10K Raster Mapping	1:10,000	2006	16
VectorMap Local	1:10,000	2016	17

Russian Map - Slice A



Order Details

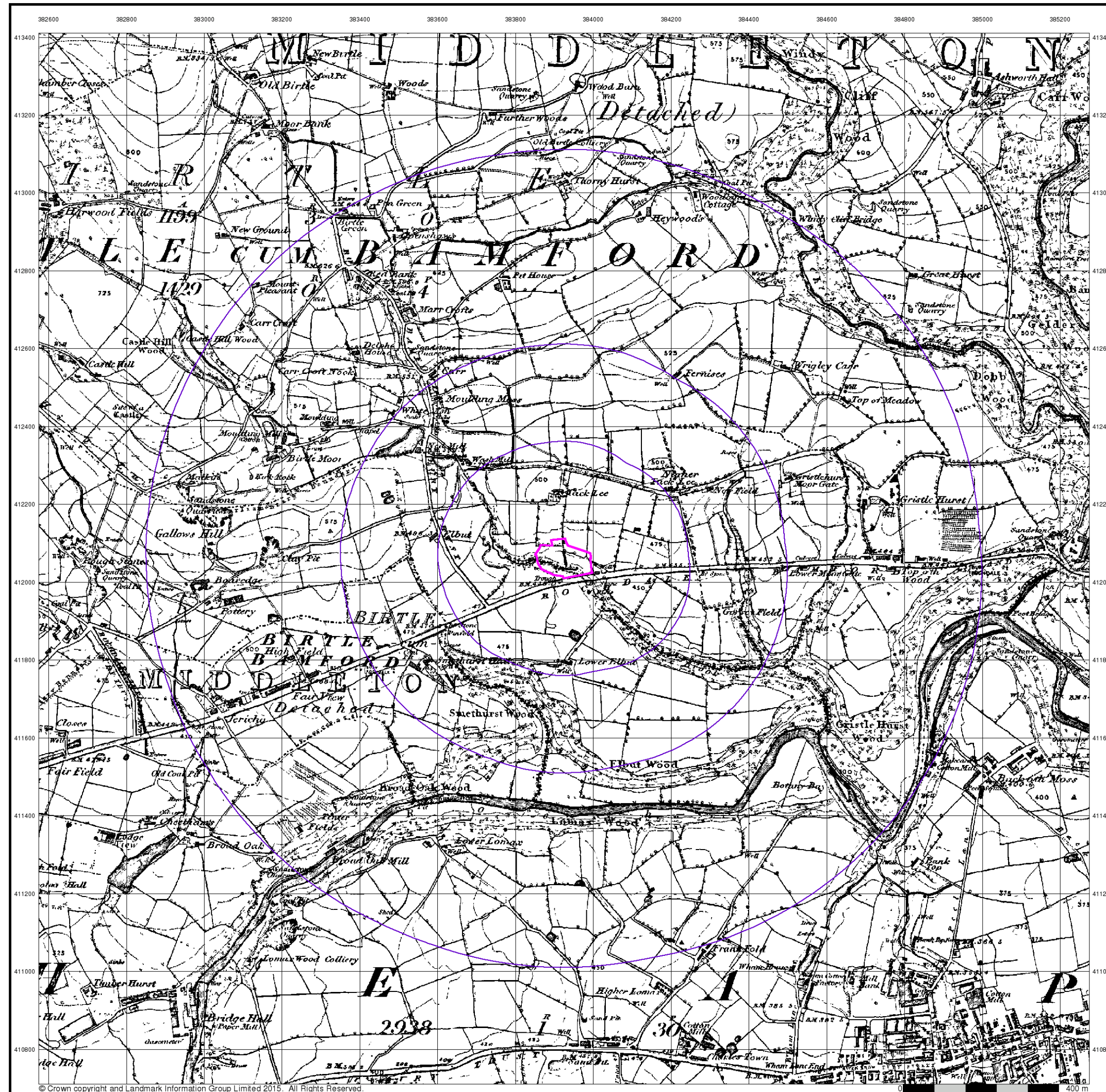
Order Number: 88327429_1_1
 Customer Ref: LKC 16 1018
 National Grid Reference: 383930, 412060
 Slice: A
 Site Area (Ha): 1.02
 Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



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 Fax: 0844 844 9951
 Web: www.envirocheck.co.uk



LK

CONSULT LIMITED

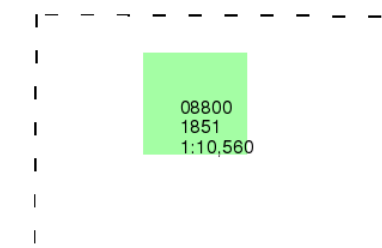
Lancashire And Furness

Published 1851

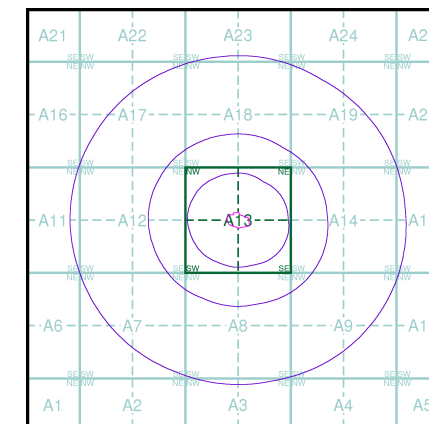
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



Order Details

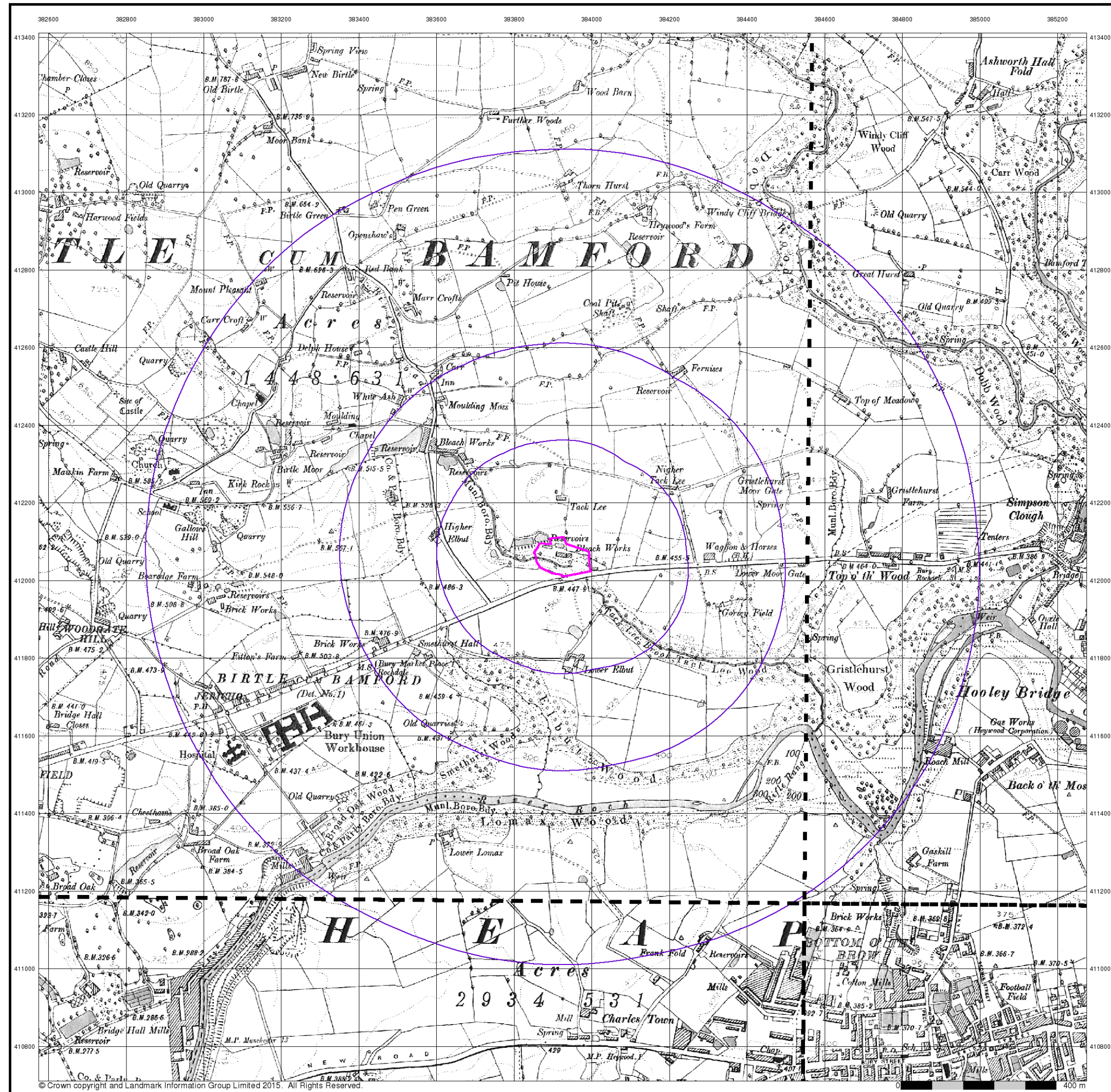
Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



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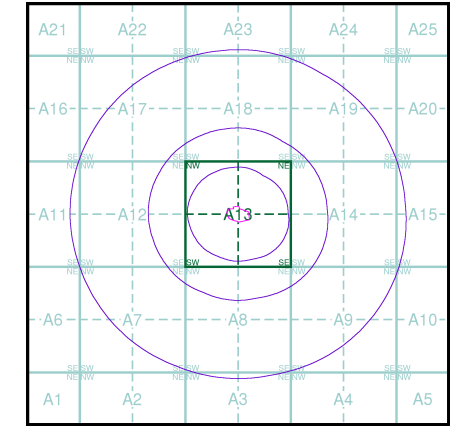
Published 1894
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

088NW 1894 1:10,560	088NE 1894 1:10,560
088SW 1894 1:10,560	088SE 1894 1:10,560

Historical Map - Slice A

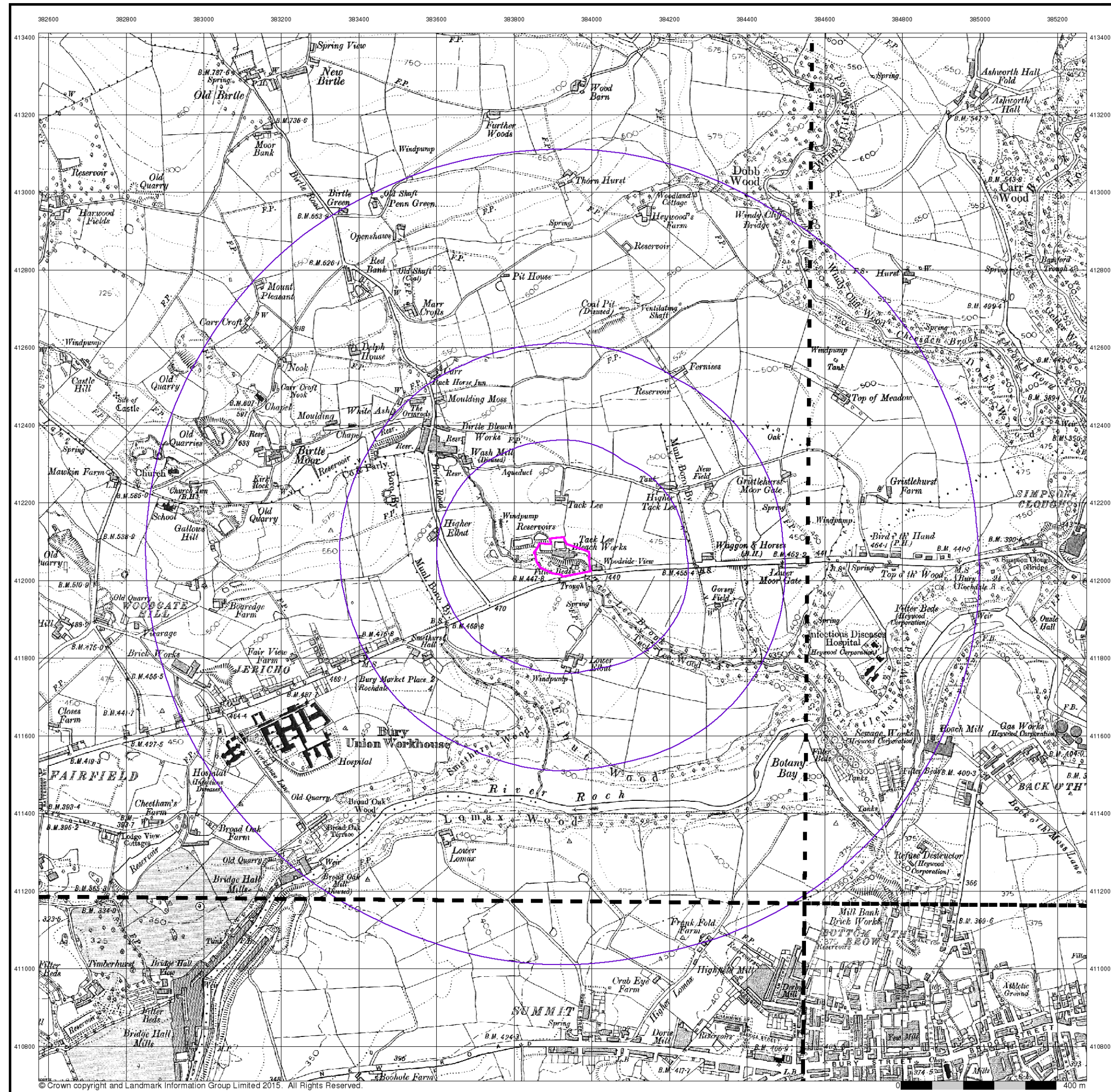


Order Details

Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



Published 1910 - 1911

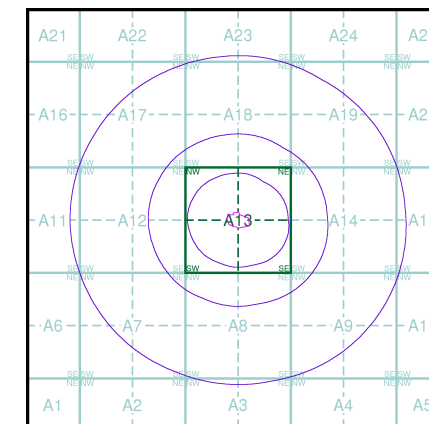
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

088NW 1911 1:10,560	088NE 1911 1:10,560
088SW 1910 1:10,560	088SE 1910 1:10,560

Historical Map - Slice A

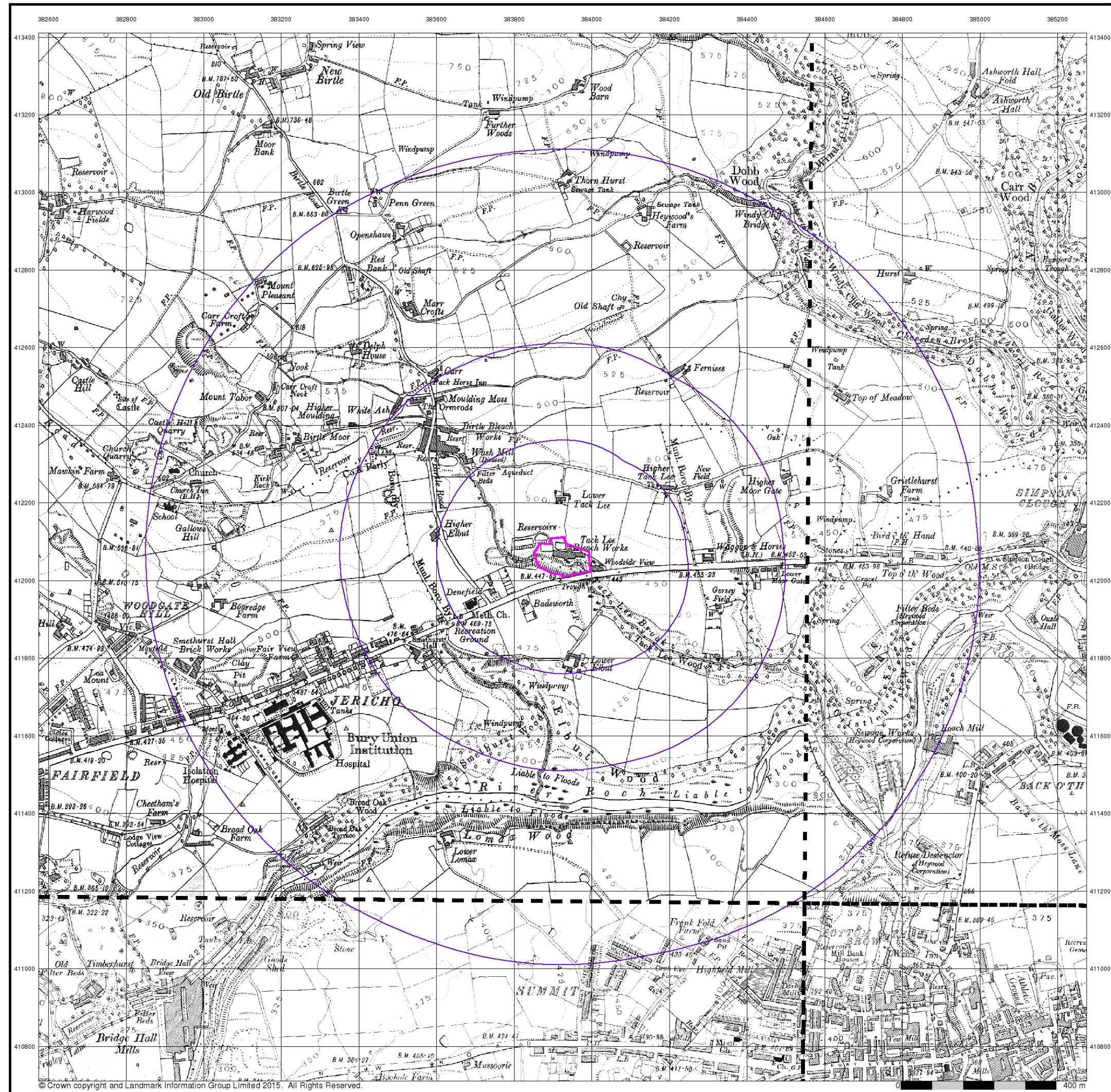


Order Details

Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



Published 1931 - 1932

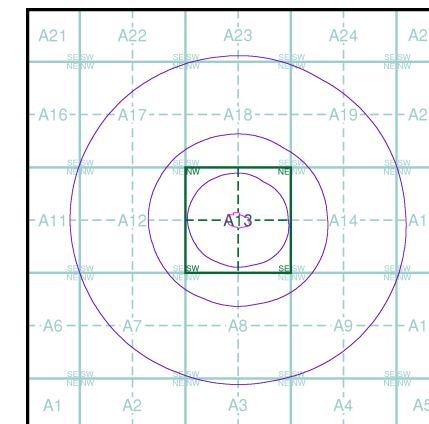
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

088NW 1931 1:10,560	088NE 1932 1:10,560
088SW 1931 1:10,560	088SE 1932 1:10,560

Historical Map - Slice A

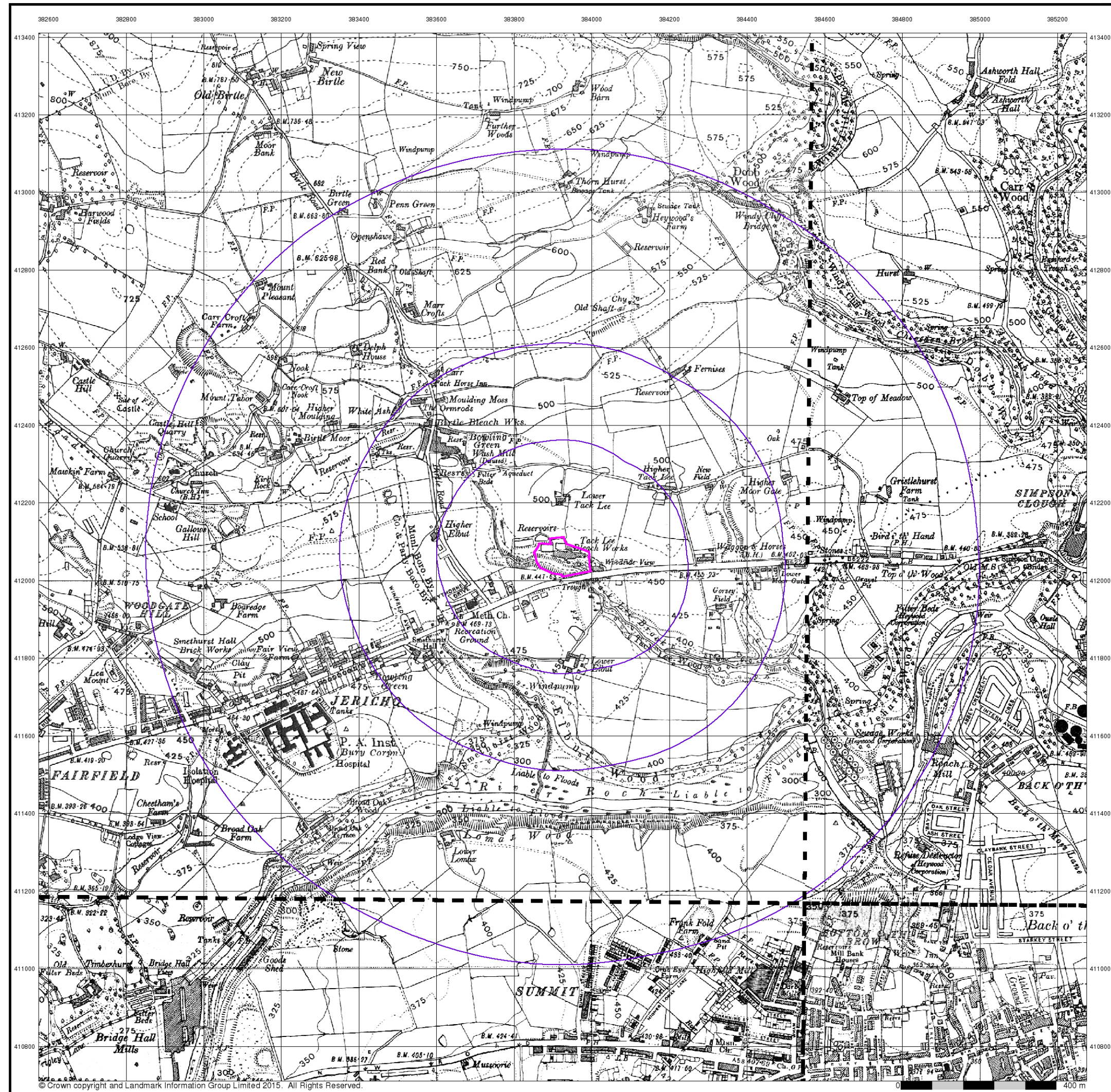


Order Details

Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



LK

CONSULT LIMITED

Lancashire And Furness

Published 1938 - 1939

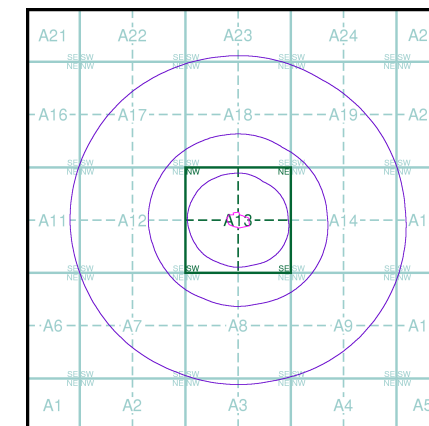
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

088NW 1939 1:10,560	088NE 1938 1:10,560
088SW 1938 1:10,560	088SE 1938 1:10,560

Historical Map - Slice A



Order Details

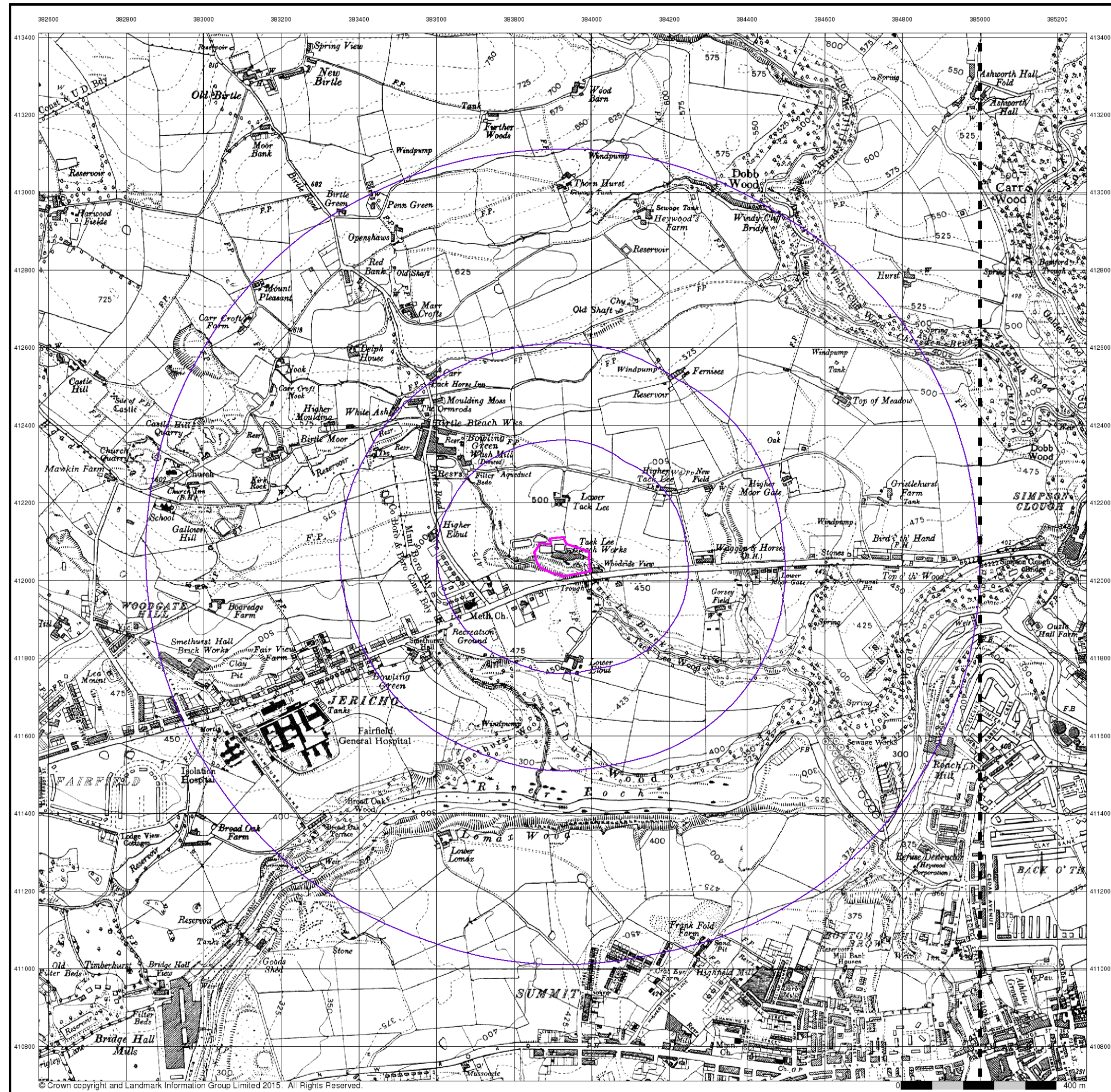
Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



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LK

CONSULT LIMITED

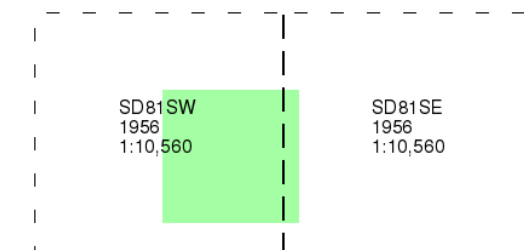
Ordnance Survey Plan

Published 1956

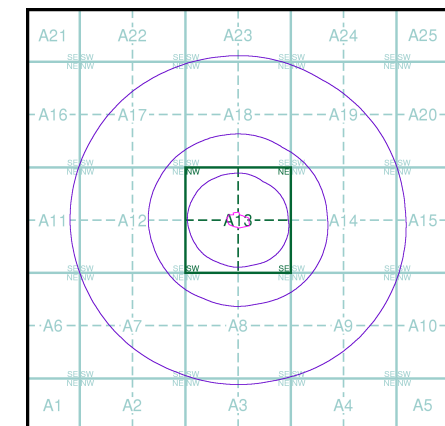
Source map scale - 1:10,000

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



Order Details

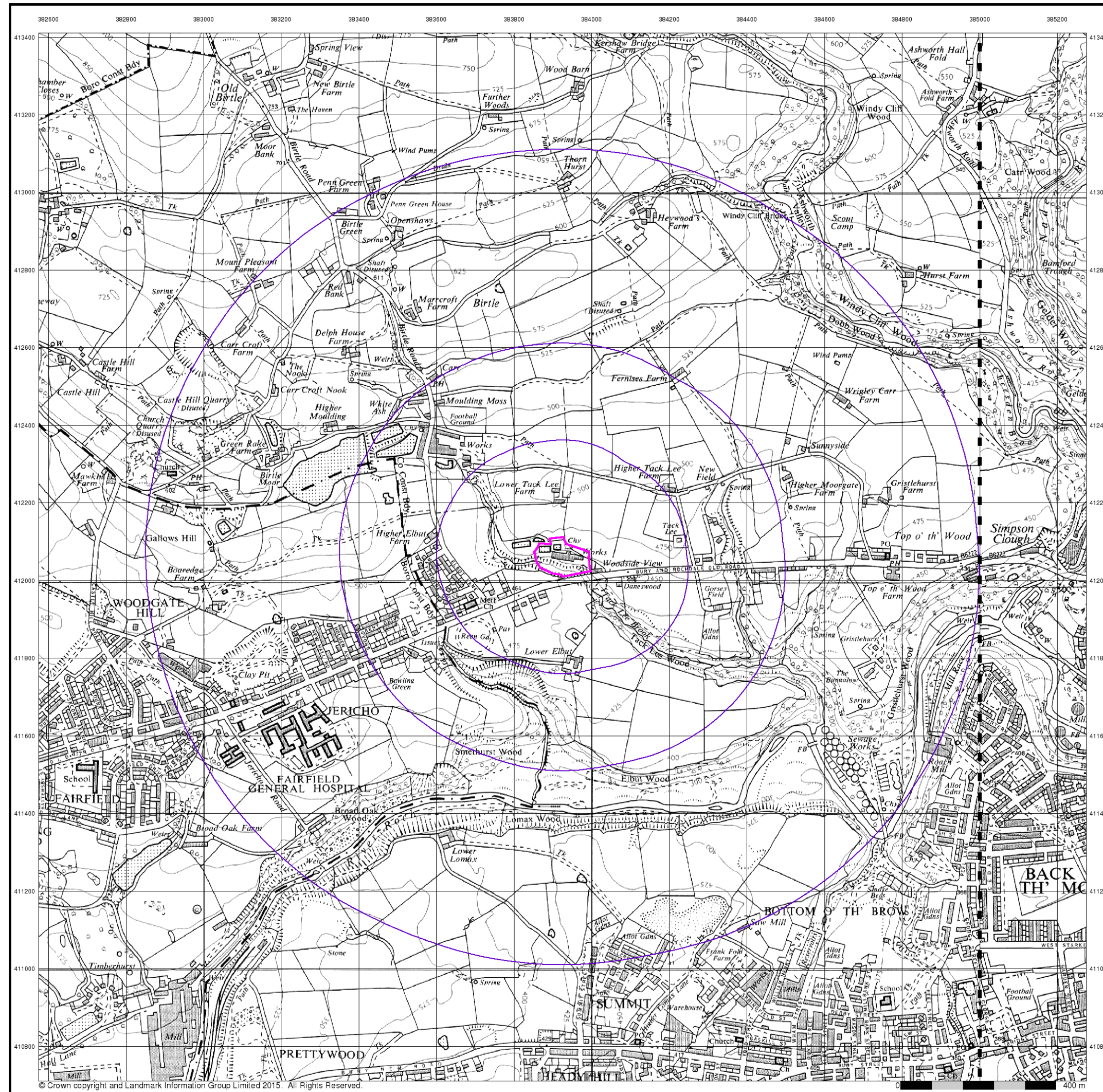
Order Number: 88327429_1_1
Customer Ref: LKC 16 1018
National Grid Reference: 383930, 412060
Slice: A
Site Area (Ha): 1.02
Search Buffer (m): 1000

Site Details

Tack Lea Works,, Bury & Rochdale Old Road, Bury, BL9 6UY



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Ordnance Survey Plan

Published 1967 - 1968

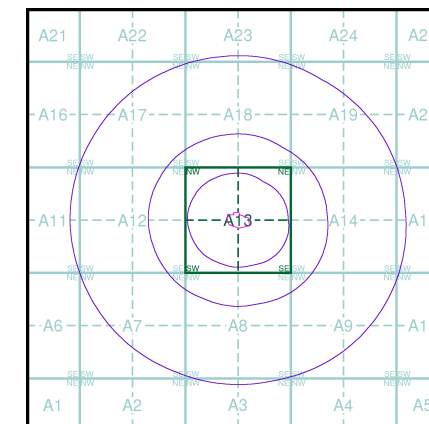
Source map scale - 1:10,000

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

SD81SW 1967 1:10,560	SD81SE 1968 1:10,560
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