GeoDyne

Geotechnical &
Environmental
Consultants

Yews Farm
Pinchbeck

Combined Phase I Desk Study and Phase II Exploratory Investigation For Ashwood Homes

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Project No: D39032		**Date: 20th January 2021**	
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EXECUTIVE SUMMARY

GEOTECHNICAL CONSIDERATIONS	
Ground Conditions	Made Ground was not encountered at the site. Topsoil was encountered at the surface in all exploratory holes to an average depth of approximately 0.35m begl. The Natural Strata typically comprised firm or stiff sandy silty CLAY, which became softer with depth. The Clay was noted to be locally interbedded with firm sandy clayey SILT in the near surface horizons. Underlying the Clay / Silt soils, loose to medium dense (locally medium dense to dense) silty SAND was encountered from depths of below 3.00m begl.
Foundation Design	Structural Engineer designed strip or raft foundations. The natural soils appear suitable to support a nett allowable ground bearing pressure of up to 75kN/m^2. Foundations should be advanced to a minimum depth of 0.90m below existing or proposed ground level (whichever being the deeper). It is important to ensure that all foundation excavations are kept as shallow as possible to avoid potential decreases in soil strength from affecting foundation integrity.
Floor Slab Design	Ground bearing floor slabs may be adopted at the site provided that there is less than 0.60m of suitably compacted geotechnically competent sub-slab fill beneath proposed slabs.
Ground Gas Precautions	No ground gas precautions relating to carbon dioxide or methane are required.
Radon	No radon precautions are required at the site.
Building Near Trees	Foundation designs may need to be adjusted where building near existing, proposed or recently removed trees and hedgerows. Medium volume change potential should be assumed for design purposes.
Water	Foundation excavations are unlikely to require dewatering. However, deeper excavations (i.e. sewers, for example) may encounter water seepage, which should be controllable utilising minor sump pumping techniques, in the first instance.
Excavations/Stability	Excavations were stable for the short period of time they were left open after completion. The assessment of excavations and provision of support will be the responsibility of the contractor on site.
Sulphate Classification	Design Class DS-1 / ACEC Class AC-1 (BRE Special Digest 1: 2005)
Coal Mining	No coal mining precautions or associated investigation works are required at the site.
CBRs	The remoulded soaked CBR testing has revealed CBR values for the Natural Strata between 0.9% and 4.7%.
Surface Water Drainage	Based on the geology encountered during the intrusive works, soakaways are unlikely to be suitable at the site. Therefore, alternative drainage solutions should be considered for the site.
ENVIRONMENTAL CONSIDERATIONS	
Soil Contamination Assessment	The soils may be considered to be uncontaminated in the context of the proposed end-use. There are considered to be no specific risks posed to Controlled Waters by the findings of the laboratory analysis undertaken.
Remediation Proposals	No specific remediation works will be required other than the provision of existing topsoil in proposed gardens and any other areas of soft landscape to provide a suitable growing media for plants.
GENERAL CONSIDERATIONS	
Construction Workers	Construction personnel should use appropriate PPE equipment and hygiene facilities.
Utilities	We would recommend that our report is supplied to utility companies and their recommendations are adhered to.
Unforeseen Circumstances	Should any areas of potentially contaminated soil/anomalous features be encountered we would recommend consultation with GeoDyne.
Flood Risk	The desk study information has revealed the site to lie within an area identified as being at risk of flooding. It is recommended that advice be sought from a Drainage Consultant with respect to this matter.
Licenses etc.	The Contractor/Developer is responsible for, and must ensure that, all necessary licenses, permits, plans, registrations and approvals are in place prior to commencing with the construction works at the site.
Statutory Consultation	We would recommend that our report is issued to the Local Authority (and NHBC or other Warranty Provider).

1.0 INTRODUCTION

1.1 Introduction

GeoDyne Limited has been appointed by the Client, Ashwood Homes, to undertake a combined Phase I Desk Study & Phase II Exploratory Investigation on land located at Yews Farm, Pinchbeck. A site location plan (Figure No. D39032/01) is included in Appendix I.

1.2 Project Understanding

We understand that it is proposed to develop the site with low-rise residential properties incorporating private gardens as shown on the draft layout plan included within Appendix II. As shown on the draft phased development plan (also included within Appendix II), the development is to be split into five development phases / parcels, referenced Phase 1 to Phase 5. At this stage it is understood that Phase 5 represents an area of proposed Public Open Space (POS).

This understanding has formed the basis of our report. Where our understanding is incorrect, it may be necessary to review our assessment to ensure that it continues to apply.

1.3 Objectives

The scope of works detailed herein have been designed to ascertain the key geotechnical and environmental issues pertaining to the proposed development.

1.4 Scope of Works

Based on the defined objectives of the works (detailed in Section 1.3), the scope of the Phase I Desk Study included the following:

- A site walkover.
- Review of available historical and contemporary Ordnance Survey publications relating to the site.
- Review of the site's geology, hydrology, hydrogeology and groundwater vulnerability.
- Review of the site's coal mining status.
- Review of the site's radon status.
- Commission of a full detailed Landmark Envirocheck Report relating to the site.
- Commission of Landmark geological mapping data.
- Production of a preliminary Conceptual Site Model (pCSM).

Phase II Exploratory Investigation works comprised:

- A sub-contracted sub-surface utility scan.
- A series of mechanically excavated trial pits across the proposed development areas (i.e. Phases 1 to 4).
- A series of window sampling boreholes across the proposed development areas (i.e. Phases 1 to 4).
- A series of hand auger holes within the proposed POS (i.e. Phase 5).
- Geotechnical and environmental soil testing.
- A initial programme of ground gas and water level monitoring across the proposed development areas (i.e. Phases 1 to 4).
- A series of window
- Revision of the pCSM.
-

1.5 Limitations

The conclusions and recommendations made in this report are limited to those that can be made based on the findings of the investigation.

Where comments are made based on information obtained from third parties, GeoDyne Limited assumes that all third party information is true and correct. No independent action has been undertaken to validate the findings of third parties.

This report has been prepared in accordance with our understanding of current good practice. However, changes to good practice, guidance or legislation may necessitate revision of this report after the date of issue.

GeoDyne Limited has prepared this report for the sole use and reliance of Ashwood Homes, in accordance with our standard Conditions & Limitations (included in Appendix XIV). This report may not be used or relied upon by any unauthorised third party without the explicit written agreement of GeoDyne Limited. Reliance may not be placed on our report until all invoices associated with the project have been paid.

2.0 SITE DESCRIPTION & HISTORY

2.1 Site Description

The site comprises an irregular shaped parcel of land located to the west of Spalding Road, Pinchbeck, Lincolnshire. The site may be located centred around approximate Ordnance Survey National Grid Reference 524170E 324560N. The site covers an area of approximately 17 hectares.

The site is separated into five areas (Phase 1 to Phase 5) which are shown on the annotated site plan within Appendix II of this report (Figure No. D39032/02). At the time of our works (November 2020), Phase 1 comprised a grassed field which was partially divided by heras fencing from neighbouring archaeological works in the same field. Phases 2, 3 and 4 comprised a single, large field which was cropped. Phase 5 comprised an overgrown field. The site was sensibly level.

Drainage ditches were present along the north eastern, northern and north western site boundaries. A drainage ditch separated the Phase 1 area from the Phase 2, 3 and 4 areas. A railway line ran north to south separating the Phase 5 area from the Phase 2, 3 and 4 areas.

To the east of the site was Spalding Road, beyond which lay an industrial estate. Further fields and residential housing were located to the north of the site towards Market Way. Market Way runs east to west along the northern site boundary. Fields were present to the west and north west of the site, beyond Blue Gowt Lane.

To the south of the site was a continuation of the fields which contain Phases 2, 3, 4 and 5. Beyond these fields was Vernatt's Drain and residential properties in Spalding.

A gas governor compound was present to the north west of the site, immediately beyond the site boundary with access off Blue Gowt Lane. An intermediate pressure gas main was present running south east from the compound along the western boundary of the Phase 2 area. A high pressure gas main was present running north east from the compound bisecting the Phase 3 and Phase 4 area. A further high pressure gas main running south west from the compound was present through the Phase 5 area.

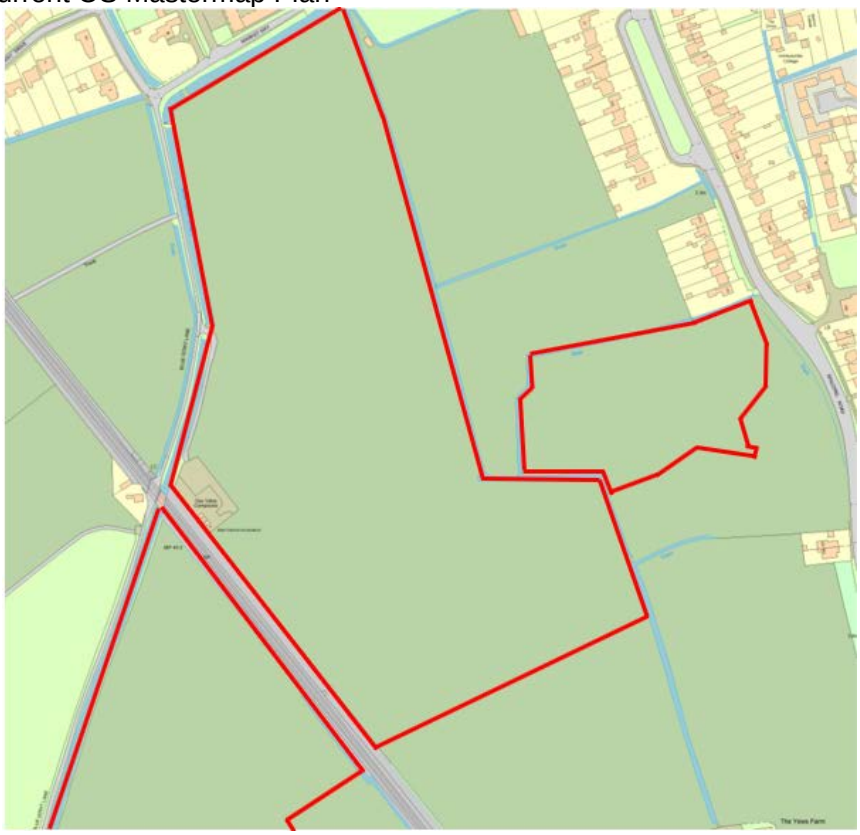
An annotated site plan showing the main features of the site and the immediate surrounding area is included as Appendix III of this report (Figure No. D39032/02) and plans showing general views of the site are included as Appendix IV (Figure No. D39032/03 and D39032/3A)

An aerial photograph of the site, obtained from the Landmark Analysis tool commissioned as part of our works, is presented in Figure 1 on the following page, with the current OS mapping plan for the site and surrounding area presented in Figure 2. It should be noted that Figures 1 and 2 do not show the far south western corner of the site due to the size limits of the mapping tool.

Figure 1: Aerial photograph of the site (2020 image)



Figure 2: Current OS Mastermap Plan



2.2 Site History

The historical and contemporary Ordnance Survey publications included within the Landmark Envirocheck Report have been reviewed by GeoDyne to establish the history of the site and its environmental setting. The historical Ordnance Survey maps are included as Appendix V of this report.

We would note that the boundary marked on the historical sheets within the Envirocheck Report appears to 'shift' on several of the maps due to scaling inaccuracies between maps of differing dates. This is a function of Envirocheck transposition algorithms. It should be noted that the Envirocheck Report portrays a slightly larger overall site area.

The key findings of the historical search are summarised in Table 1.

TABLE 1 – HISTORICAL PUBLICATION DATA

Date	Features on Site	Features off Site
1880s	• The site comprises parts of five undeveloped (potentially agricultural) fields. The fields are separated by drains. • One drain runs from the north through the site before turning east and connecting to another drain on the site boundary. • Two of the western fields are separated by the *'Great Northern & Great Eastern Joint Railway Line'* which runs from north west to south east. • The site is generally bound by drains, apart for the south eastern and eastern boundaries.	• The area surrounding the site generally comprises further fields with drains. • '*Spalding Road'* is located to the east of the site, '*Market Way'* is located to the north of the site and *'Blue Gowt Lane'* is located to the north west of the site. • Several small properties are located within the area surrounding the site. • Vernatt's Drain, a large open drain, is located approximately 80m south of the site at it's closest point. • A *'Brickworks*' is located approximately 200m south of the site, beyond Vernatt's Drain.
1890s	• No maps available for viewing.	• No maps available for viewing.
1900s	• The drain forming the north western site boundary is referenced as *'Blue Gowt Drain*'.	• The *'Brickworks*' to the south of the site is no longer shown and the associated excavation appears to a comprise a large body of water.
1910s and 1920s	• No maps available for viewing.	• No maps available for viewing.
1930s	• The site remains essentially unchanged.	• *'Allotment Gardens'* are shown to the north west of the site beyond Blue Gowt Lane.
1940s	• No maps available for viewing.	• No maps available for viewing.
1950s	• The site remains essentially unchanged.	• A number of residential properties have been built to the north east of the site.
1960s	• The drain through the site from the north now appears to be partially infilled, with the northern section no longer shown. The eastern section is still present and connected to the drain on the site boundary.	• A small gas governor compound has been constructed to the immediate north west of the site, between the site boundary and Blue Gowt Lane. • A *'Nursery*' is shown to the immediate east of the site. • The body of water associated with the former brickworks is no longer shown, which suggests it has been infilled. • Residential properties have been built to the north of the site along *'Market Way*'.
1970s	• The site remains essentially unchanged.	• The area surrounding the site remains essentially unchanged.

TABLE 1 – HISTORICAL PUBLICATION DATA		
Date	Features on Site	Features off Site
1980s	• The site remains essentially unchanged.	• Large scale residential development has occurred to the north of the site in Pinchbeck. • The *'Nursery'* to the east of the site is no longer referenced.
1990s	• The 1999 Aerial Photo shows the site under use as agricultural land. The majority of the partially infilled drain is not present, however the eastern portion is still shown on the mapping from the early 1990s.	• The area surrounding the site remains essentially unchanged.
2000	• The site remains essentially unchanged.	• An industrial estate has been built to the east of the site, beyond Spalding Road.
2006 and 2020	• The site remains essentially unchanged.	• The area surrounding the site remains essentially unchanged.

2.3 Aerial Photography & Historical Map Overlays

As part of the commissioned Landmark Report, the use of the Landmark Envirocheck Analysis tool was purchased to provide site specific aerial photographic imagery, and to provide the ability to undertake limited historical map overlay manipulation.

The following pictures (Figures 3 & 4) show overlays of the historical map publications, as shown on current aerial imagery.

Figure 3: Current Aerial Imagery Overlain with 1956 Historical Map Data.



The former drain running through the site is visible, together with the railway line through the site. The allotment gardens are shown to the north west of the site.

Figure 4: Current Aerial Imagery Overlain with 1980 Historical Map Data.



The former drain running through the site appears to now be partially infilled. The allotment gardens are no longer present to the north west.

3.0 GEOLOGY & ENVIRONMENTAL SETTING

3.1 Geological References

The following geological publications were referred to:

- BGS 1:50000 Series Sheet 144 *'Spalding'* (1992).
- Landmark geological map sheets (included in Appendix VI).
- The BGS online interactive map viewer and Lexicon of Named Rock Units.
- The Coal Authority online interactive map viewer.

3.2 Geology

The entire site and immediate surrounding area are indicated to be underlain by superficial drift deposits comprising Tidal Flat Deposits (formerly referred to as the Terrington Beds), which date from the Quaternary. These deposits are typically described as marine alluvium comprising salt marsh, tidal creek and river deposits (i.e. sandy silt, sand and clay). Drift deposits have the potential to alter rapidly in character and geotechnical properties both laterally and vertically over relatively short distances and may also be water bearing. Tidal Flat Deposits may also contain peat as pockets, lenses or discrete layers.

Beneath the drift deposits across the entirety of the site, bedrock of the Oxford Clay Formation is indicated to be present, which dates from the Jurassic. The Oxford Clay Formation is described on the BGS Lexicon of Named Rock Units as *'Silicate-mudstone, grey, generally smooth to slightly silty, with sporadic beds of argillaceous limestone nodules'.*

3.3 Faults

No faults are indicated to be present within the boundary of the site or within the immediate vicinity of the site, on the geological maps viewed.

3.4 Man-Made Deposits

The geological publications do not show the presence of any man-made deposits (i.e. Made Ground, Worked Ground or Landscaped Ground) beneath the site, or within a 250m radius of the site. We would note however the potential presence of Made Ground at the site associated with the former drain that used to pass through the central portion of the site (see Table 1 and Figures 3 & 4).

Made Ground may also be present associated with infilled former ponds and drains in close proximity to the site and in the area of the historic landfill (infilled brickworks excavation) indicated to the south of the site (see Section 3.5.2).

Any infill materials to these features are considered to represent potential sources of hazardous ground gas (i.e. carbon dioxide and methane) that may, under the right circumstances, affect the proposed development site. However, due to the small scale of these features and the distance to the former landfill, the risk of ground gas generation is considered to be very low.

3.5 Landmark Envirocheck Report

A Landmark Envirocheck Report was commissioned to assist in ascertaining the environmental setting of the site. The full Envirocheck Report is presented in Appendix VII and has revealed the following key relevant information (details are only listed where they are within potential influencing distance of the site).

3.5.1 Agency and Hydrological

Aquifer Status

The aquifer designation maps are presented in Appendix VII and are based on geological mapping provided to Landmark by the British Geological Survey. Different aquifer classifications may be applied to superficial (drift) deposits (typically forming shallow perched groundwater units where present) and bedrock aquifers (which may contain regional groundwater units). Possible aquifer designations comprise Principal Aquifers, Secondary (A, B or Undifferentiated) Aquifers and Unproductive Strata.

The superficial deposits (i.e. Tidal Flat Deposits) and the underlying bedrock (i.e. Oxford Clay Formation) are classified as *'Unproductive Strata'*.

Unproductive Strata are described by the Environment Agency as *'rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.*'

Source Protection Zone Status

The site is not shown to lie within a Source Protection Zone (SPZ), as designated by the Environment Agency. SPZs relate to the protection of groundwater resources principally for public drinking water supply.

Flood Risk Status & BGS Groundwater Flooding Susceptibility

The site is indicated to be situated within an area at extreme risk from flooding from rivers or sea without defences. However, the map included in Appendix VII within the Landmark report indicates that localised areas of the site are at a low to medium risk of flooding from surface water.

The Landmark report indicates that the site does not lie within an area with potential for groundwater flooding to occur at the surface.

This report does not constitute a formal flood risk assessment.

Water Abstractions

There are five entries listed within 250m of the site. All relate to the abstraction of water for spray irrigation. The nearest entry is located 2m west of the site operated by Cecil Francis Ltd. The license has been revoked.

Pollution Incidents to Controlled Waters

There are five entries listed within 250m of the site. The incidents occurred between 20m and 197m from the site. The nearest entry, 20m north east of the site occurred in 1993 and was classed as a minor incident.

Substantiated Pollution Incident Register

There is one entry listed within 250m of the site, located 171m south west of the site. The incident occurred in 2015 and is recorded as a Category 2 – Significant Impact on waters, and Category 4 – No Impact for air and land. No other details are provided.

Discharge Consents

There is one entry within 250m of the site. This was operated by Ashwood Homes between 1988 and 1996 discharging water onto land from a domestic property.

Surface Water

The nearest surface water feature is indicated to be present on site. This relates to the drain, which is present along the site boundary.

3.5.2 Waste

Landfill Sites

There is one entry for a Historic Landfill site located approximately 184m south of the south. No details regarding the type of waste, operator or dates of operation are supplied. Based on the historical mapping, the landfill is no longer active and the location corresponds to the former location of the brick works excavation as revealed on the historical maps.

Potentially Infilled Land (Water)

There are no Potentially Infilled Land (Water) entries at the site. However, a former drain was identified in the historical maps in Table 1. The drain is no longer present on site and is presumed to have been infilled.

There are seven entries within 250m of the site. These all relate to unknown filled ground between 17m and 242m from the site. These are likely to represent infilled drains and small ponds which are common in the surrounding area.

3.5.3 Hazardous Substances

There are no sites associated with hazardous substances (i.e. sites dealing with explosives etc.) identified on the site, or within a 250m radius of the site, in the Landmark Envirocheck Report.

3.5.4 Geological Issues

BGS Soil Chemistry

The BGS has prepared estimated soil concentration maps for several metals (including Arsenic, Lead, Nickel, Chromium and Cadmium), which are extrapolated from records available for use within their assessments.

Whilst potentially useful for the inference of Natural Metal Enrichment (NME) of the natural soils in a general locale, the data should not be used to inform any detailed decisions with regards to the chemistry of a particular site as it does not allow for anthropogenic effects. Estimates of the soil chemistry at the site indicate anticipated concentrations of Arsenic of <15mg/kg, Cadmium of <1.8mg/kg, Chromium of 60-90mg/kg, Lead <100mg/kg and Nickel of 15-30mg/kg.

Based on the information supplied within the Envirocheck report, the site is not shown to be located within an area where Natural Metal Enrichment of the underlying natural soils is likely to be present. However, this is only applicable to the specific determinands listed above.

Ground Stability Hazards

No significant ground stability hazards have been identified by the Landmark Envirocheck Report that relate to the site (including from collapsible, ground dissolution, landslide and shrinking or swelling clay ground stability hazards). However, it should be noted that the site is listed as having a Moderate Hazard Potential associated with both the Potential for Compressible Ground and Running Sand.

Radon

The Landmark Envirocheck Report identifies that the site lies within a lower probability Radon area and no Radon protective measures are necessary in the construction of new dwellings or extensions.

BGS Borehole Records

There are no BGS borehole records for the site or within the immediate vicinity of the site.

3.5.5 Industrial Land Use

There are no industrial land use entries identified at the site.

Contemporary Trade Directory Entries

There are three contemporary trade directory entries recorded within 250m of the site comprising one active entry and two inactive entries.

The active entry relates to domestic cleaning services (200m to the north of the site).

The inactive entries relate to a food products manufacturer (176m to the north east of the site) and a road haulage services (220m south of the site).

3.5.6 Sensitive Land Use

The site is identified as being within a Nitrate Vulnerable Zone. In our experience the majority of this area of the country is defined as a Nitrate Vulnerable Zone and this classification is considered not to present a potential risk to the site.

3.6 Land Use Assessment

As part of the land use assessment, reference has been made to the *'Desk Reference Guide to potentially Contaminative Land Uses'* produced by Mr P Syms and published jointly by the ISVA (The professional Society for Valuers and Auctioneers) in association with The Royal Institution of Chartered Surveyors (RICS) and the Chartered Institute of Environmental Health (CIEH).

We have also made reference to the Department for Environment, Food and Rural Affairs and the Environment Agency Contaminated Land Report CLR8 '*Potential Contaminants for the Assessment of Land*' (March 2002). Although now formally withdrawn, this document identifies key contaminants which may potentially be present at a site as a result of a given historical land use and is considered useful as a desk based ready reference guide.

3.6.1 On Site Assessment

At the time of our works (November 2020), the site essentially comprised three undeveloped, sensibly level fields. Based on the reviewed historical information, the site has essentially remained unchanged according to the earliest available historical maps of the 1880s.

Based on the information obtained from our desk study enquiries, our walkover of the site and experience of similar sites, potential general soil contamination that may be present could include:

- Metals and metalloids associated with any potential localised Made Ground beneath the site.
- Polycyclic Aromatic Hydrocarbons (PAHs) from any ashy inclusions and/or carbonaceous inclusions in the near surface soils.
- Pesticides associated with the agricultural use of the site.
- Hazardous ground gases (i.e. methane and carbon dioxide) associated with any localised Made Ground associated with the potential infilling of the former drain or within any natural peat / organic deposits potentially beneath the site.

3.6.2 Off Site Assessment

The site lies within an area dominated by agricultural fields and residential properties. With regards to potential sources of chemical contamination, based on the findings of the Phase I Desk Study enquiries, there are no significant potentially contaminative land uses known to be present within close proximity to the site.

Based on the information obtained from the desk study, the following sources of potentially hazardous ground gas (i.e. carbon dioxide and methane) have been identified within potential influencing distance (i.e. <250m) of the site:

- Made Ground potentially associated with infill materials to the former drains ditches and ponds in close proximity the site, and the historic landfill located to the south of the site.

4.0 PRELIMINARY CONCEPTUAL SITE MODEL

4.1 General

The DEFRA publication '*Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance*' (dated April 2012) states the following with regards to the production of a Conceptual Site Model (CSM) for a site:

'*The process of risk assessment involves understanding the risks presented by land, and the associated uncertainties. In practice, this understanding is usually developed and communicated in the form of a "conceptual model"*'. The development of a CSM is typically undertaken in an iterative process, reflecting the changes in understanding as more detailed site information becomes available.

In developing a CSM, and specifically in the context of land contamination, consideration needs to be given to three essential elements; which form the basis of any risk present. The statutory guidance sections 3.8 and 3.9 (April 2012) states the following:

(a) '*A "contaminant" is a substance which is in, on or under the land and which has the potential to cause significant harm to a relevant receptor, or to cause significant pollution of controlled waters.*
(b) A "receptor" is something that could be adversely affected by a contaminant, for example a person, an organism, and ecosystem, property, or controlled waters...
(c) A "pathway" is a route by which a receptor is or might be affected by a contaminant.

The term "contaminant linkage" means the relationship between a contaminant, a pathway and a receptor.' For a contaminant linkage to be plausible, all three elements need to be present.

In undertaking a risk assessment and deriving a CSM for the purposes of the redevelopment of a site (i.e. planning and development control) reference has been made to both the Model Procedures for the Management of Land Contamination, as well as the National Planning Policy Framework (NPPF, dated July 2018).

The preliminary CSM should identify the hazards (source of potential contamination) and should set out the potential pollutant linkages with a view to identifying the nature and magnitude of the potential risks to receptors.

In order to undertake the foregoing assessment, consideration is required with respect to the probability or likelihood of the linkage occurring and the severity and significance of the potential consequences; taking account the nature of the pollutant linkage and the potential severity of the hazard and the sensitivity of the receptor within the context of the proposed land use (in consideration of the planning regime).

Consideration of consequence/severity, probability/likelihood and risk has been based on the following guidance documentation:

- CIRIA C552 '*Contaminated Land Risk Assessment, A Guide to Good Practice*', 2001.
- EA R&D publication 66 '*Guidance for the Safe Development of Housing on Land Affected by Contamination*', 2008.

4.2 Classification of Consequences

In order to apply a consequence classification to a particular potential pollutant linkage, it is first necessary to define the terminology used within the classification system. The following terminology and definitions detailed in Table 2 have been adopted within our assessment, based on the guidance referenced in Section 4.1.

TABLE 2 – CLASSIFICATION OF CONSEQUENCES

Classification	Definition
Severe	• Acute risks to human health. • Short-term risk of pollution of controlled waters or significant impact on controlled waters; e.g. large-scale pollution or very high levels of contamination. • Catastrophic damage to buildings or property (such as building explosion causing collapse). • Ecological system effects – immediate risks of major damage which is likely to result in irreversible substantial adverse changes in the functioning of the ecosystem or harm to a species of special interest that endangers the long-term maintenance of the population.
Medium	• Chronic risks to human health. • Pollution of sensitive water resources (such as leaching of contaminants into controlled waters) causing a significant effect on water quality. • Ecological system effects – Immediate risks of significant damage which may result in substantial adverse changes to the ecosystems functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. • Significant damage to buildings, structures and services (for example foundation damage or rendering the building unsuitable for habitation).
Mild	• Non-permanent health effects to human health (i.e. exposure is unlikely to lead to 'significant harm' in the context of Part 2A of the Environmental Protection Act 1990. • Pollution of controlled waters or non-sensitive water resources (for example non-classified groundwater) that results in a short-lived effect to water quality or a marginal effect on amenity value, agriculture or commerce. • Minor damage to buildings, structures and services. • Ecological system effects – Minor or short-term damage which is unlikely to result in substantial adverse changes to the ecosystems functioning or harm to a species of special interest. • Substantial damage to non-sensitive environments (such as arable farmland for example).
Minor	• No measurable effects on human health including non-permanent health effects to human health that are easily preventable by appropriate use of PPE/RPE. • Minor pollution of controlled waters including non-sensitive water resources with no discernible effects on water quality or ecosystems. • Minor damage to non-sensitive environments (including arable farmland for example). • Easily repairable effects of damage to buildings, structures, services or the environment (for example discolouration of concrete, loss of plants in a landscaping scheme etc.).

4.3 Classification of Probability

Once the possibility of a pollutant linkage has been established (noting that probability classification does not apply when there is no possibility of a linkage being present), the probability should be classified in accordance with Table 3.

TABLE 3 – CLASSIFICATION OF PROBABILITY		
Classification	Definition	Likelihood
High Likelihood	There is a pollutant linkage and an event is highly likely to occur in the short-term, and is almost inevitable over the long-term OR there is evidence at the receptor of harm or pollution occurring.	>95% likelihood of Consequence Occurring
Likely	There is a pollutant linkage and it is probable that an event will occur. It is not inevitable, but possible in the short-term and likely over the long-term.	50 – 95% likelihood of Consequence Occurring
Low Likelihood	There is a pollutant linkage and circumstances are possible under which an event could occur. It is by no means certain that even over a longer period such an event would take place, and less likely in the short-term.	5 – 49% likelihood of Consequence Occurring
Unlikely	There is a pollutant linkage and it is improbable that an event would occur even in the very long-term.	<5% likelihood of Consequence Occurring

4.4 Classification of Risk

In order to establish the relevant risk term applicable to the identified pollutant linkage, one of the risk phrases identified within Table 4 must be adopted, with the definitions of each risk term detailed within Table 5.

TABLE 4 - RISK CLASSIFICATION MATRIX (BASED ON C552 CIRIA, 2001)					
		Consequence of Risk			
		Severe	Medium	Mild	Minor
Probability (Likelihood)	High Likelihood	Very High	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low Likelihood	Moderate	Moderate/Low	Low	Negligible
	Unlikely	Moderate/Low	Low	Negligible	Negligible or No Potential Risk

TABLE 5 - RISK CLASSIFICATION DEFINITIONS (BASED ON C552 CIRIA, 2001)	
Very High	There is a high probability that severe harm will arise to a designated receptor from an identified hazard OR there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, there is a low likelihood that such harm would be severe, or if any harm were to occur it is more likely that the harm would be mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Moderate/Low	It is possible that harm could arise to a receptor. However, a combination of likelihood and consequence results in a risk that is above low but is not of sufficient concern to be classified as moderate. It can be driven by cases where there is an acute risk which carries a severe consequence, but where the exposure is unlikely. Such harm would at worst normally be mild. The risk is unlikely to present a substantial liability. Some limited further investigation may be required to clarify the risk and any associated liability. If subsequent remediation works are necessary, they are likely to be limited in extent.
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Negligible	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is unlikely to be any worse than mild. No liability would be associated with such risks.
No Potential Risk	There is no potential risk or liability where no pollutant linkage has been established.

4.5 Contaminant [C] - Pathway [P] - Receptor [R] Considerations

The following CPR assessment has been undertaken based on the assumption of a residential with plant uptake end-use for the proposed development.

4.6 Consideration of Potential Sources of Contamination [C]

Based on the findings of our desk study works, the potential key sources of contamination at the site that would require consideration for the derivation of a preliminary CSM would be the following:

TABLE 6 – SUMMARY OF POTENTIAL CONTAMINANT SOURCES	
Areas of Potential Concern (APCs)	Associated Contaminants
Near Surface Soils (including potential localised Made Ground)	• Metals & Metalloids. • PAHs. • Pesticides. • Ground gases (including methane & carbon dioxide).
Off-Site Infilled Features	• Ground gases (including methane & carbon dioxide).

4.7 Consideration of Potential Pathways [P]

The potential pathways at the site are primarily:

- Direct ingestion of soil (either directly or as soil particles attached to produce).
- Inhalation of fugitive dust and vapours.
- Direct skin contact with the ground.
- Direct ground contact with construction materials (including supply pipes).
- Vertical and lateral migration of contamination.
- Vertical and lateral migration of potentially hazardous ground gases/vapours.

4.8 Consideration of Potential Receptors [R]

The potential receptors at the site are:

- The final end users (residents - typically long term (chronic) exposure) and site visitors – (typically short term (acute) exposure).
- The construction personnel (i.e. site workers) involved with the development of the site (typically short term (acute) exposure).
- Neighbouring properties (off-site receptors).
- Controlled Waters (i.e. underlying groundwater and nearby surface waters).
- Buildings and construction materials (including buried utilities).

In preparing this CSM, it has been assumed that construction personnel involved with the development of the site (typically short term (acute) exposure) will adopt all necessary personal protective equipment (PPE and RPE etc.) and conform to health and safety requirements of their site-specific Risk Assessments and Method Statements (RAMS). Site workers have therefore not been included within the following table, as the adoption of these appropriate mitigation measures will result in an overall low risk of exposure to the C-P-R linkages identified.

4.9 Preliminary Risk Assessment / Conceptual Site Model

Our preliminary conceptual model of possible pollutant linkages, applicable to the proposed site usage and based on our current understanding, is summarised in Table 7.

TABLE 7 – PRELIMINARY RISK ASSESSMENT SUMMARY TABLE DESK STUDY						
Potential Contaminant Source [C]	Potential Pathway(s) [P]	Potential Receptor [R]	Probability of CPR Linkage	Consequence of CPR Linkage	Risk Level	Comments / Justification
Near Surface Soils (including potential localised Made Ground)	Direct contact, ingestion or inhalation of fugitive dust	End users	Likely	Medium	Moderate	Localised Made Ground may be present on site, associated with infill materials to a former drain. No potentially significant historical contaminative land uses have been identified at the site. End users are likely to come into contact with the in-situ soils. Further consideration of this potential linkage should be provided during the course of the Phase II Exploratory Investigation works.
	Plant uptake	End users	Likely	Medium	Moderate	Localised Made Ground may be present on site, associated with infill materials to a former drain. No potentially significant historical contaminative land uses have been identified at the site. Growing of vegetables for private consumption may be anticipated at the site. Further consideration of this potential linkage should be provided during the course of the Phase II Exploratory Investigation works.
	Vertical and lateral migration	Neighbouring properties	Low Likelihood	Medium	Moderate/Low	Localised Made Ground may be present on site, associated with infill materials to a former drain. No potentially significant historical contaminative land uses have been identified at the site. No sources of potentially mobile contamination have been identified. Further consideration of this potential linkage should be provided during the course of the Phase II Exploratory Investigation works.
	Leaching of contaminants through unsaturated zone and/or vertical and lateral migration	Controlled Waters	Low Likelihood	Medium	Moderate/Low	Localised Made Ground may be present on site, associated with infill materials to a former drain. No potentially significant historical contaminative land uses have been identified at the site. No sources of potentially mobile contamination have been identified. Both the underlying superficial (drift) deposits and bedrock are classified as Unproductive Strata. The site does not lie within a designated SPZ. A drain is present to the immediate west and south of the site. Further consideration of this potential linkage should be provided during the course of the Phase II Exploratory Investigation works.

TABLE 7 – PRELIMINARY RISK ASSESSMENT SUMMARY TABLE DESK STUDY						
Potential Contaminant Source [C]	Potential Pathway(s) [P]	Potential Receptor [R]	Probability of CPR Linkage	Consequence of CPR Linkage	Risk Level	Comments / Justification
	Direct contact or contact with vapours	Plastic buildings products (e.g. water supply pipes) and buried concrete	Low Likelihood	Mild	Low	Localised Made Ground may be present on site, associated with infill materials to a former drain. No potentially significant historical contaminative land uses have been identified at the site. Any localised Made Ground may contain elevated levels of contaminants that may affect plastic building products. Further consideration of this potential linkage should be provided during the course of the Phase II Exploratory Investigation works.
	Vertical and lateral migration of ground gases to indoor air	End users of new buildings (asphyxiation) or new buildings (damage via explosion)	Low Likelihood	Severe	Moderate	Localised Made Ground may be present on site, associated with infill materials to a former drain. Peat / organic deposits may also be present beneath the site. These deposits may represent potential sources of hazardous ground gases. Phase II Exploratory works will provide further information relating to the possible presence of significant depths of Made Ground at the site.
Off-Site Infilled Features	Vertical and lateral migration of ground gases to indoor air	End users of new buildings (asphyxiation) or new buildings (damage via explosion)	Low Likelihood	Severe	Moderate	Made Ground potentially associated with infill materials to former drains and ponds around the site may represent potential sources of hazardous ground gases. A historic landfill is located to the south of the site, which also represents a potential source of ground gas. Further consideration of this potential linkage (including a programme of ground gas monitoring) should be provided during the course of the Phase II Exploratory Investigation works.

The foregoing preliminary conceptual model highlights the potential plausible pollutant linkages that may relate to the site and would therefore require addressing by appropriate Phase II Exploratory Works. The information contained within the conceptual model should be confirmed and revised upon completion of an appropriate intrusive investigation, as detailed in the following sections.

5.0 GROUND INVESTIGATION

5.1 Introduction

Sub-Surface Utility Avoidance Scan

Prior to the commencement of our intrusive works at the site a sub-contracted sub-surface utility scan was undertaken to attempt to avoid buried services during the intrusive works. Based on the results of the service scan and taking account of the requirement to avoid buried services, the exploratory holes were positioned to maximise the amount of information obtained at the site. As shown on the annotated site plan in Appendix III (Figure No. D39032/02), the route of several gas mains and a water main pass through the site.

Trial Pits

A total of thirty-eight trial pits (TP1 to TP38) were excavated at the site between 23rd and 26th November 2020 within the proposed development areas (i.e. Phases 1 to 4). The pits were excavated to depths of up to 3.20m below existing ground level (begl).

Window Sampling Borehole Works

Ten window sampling boreholes (WS1 to WS10) were advanced at the site on 25th and 26th November 2020 within the proposed development areas (i.e. Phases 1 to 4). The boreholes were advanced to a depth of 5.00m below existing ground level (begl).

Standard Penetration Tests (SPTs) were undertaken generally at 1m centres in order to provide initial strength data for the near surface soils.

Following completion, five of the window sampling boreholes (WS1 to WS5) were installed with combined ground gas and water monitoring wells in order to facilitate an initial programme of ground gas and water level monitoring.

Hand Auger Holes

Six hand auger holes (HA1 to WS6) were advanced at the site on the 30th November 2020 within the proposed area of POS (i.e. Phase 5) to a depth of approximately 0.60m begl.

Exploratory Hole Locations/Logs

The approximate locations of the exploratory holes are indicated on the plan presented in Appendix VIII of this report (Figure No. D39032/04). The exploratory hole logs are presented in Appendix IX of this report.

5.2 Ground Conditions

The general ground conditions encountered across the site may be summarised as follows.

5.2.1 Made Ground

Made Ground was not identified in any of the exploratory holes advanced at the site. No evidence of the infilled drain was encountered, as identified from historical maps.

5.2.2 Topsoil

Natural Topsoil was encountered at the surface of the exploratory holes to depths 0.20m and 0.45m begl. The average thickness of the Topsoil across the proposed development areas (i.e. Phases 1 to 4) was 0.35m begl. The Topsoil was logged as 'Disturbed' as a result of historical agricultural activities (i.e. ploughing).

5.2.3 Natural Strata

Beneath the Topsoil, the Natural Strata typically comprised firm or stiff sandy silty CLAY which became softer with depth. The Clay was noted to be locally interbedded with firm sandy clayey SILT in the near surface horizons.

Underlying the Clay / Silt soils, loose to medium dense (locally medium dense to dense) silty SAND was encountered, from depths of below approximately 3.00m begl.

The soils are considered to be typically representative of Tidal Flat Deposits, which are indicated by geological publications to underlie the site.

5.3 Visual & Olfactory Evidence of Soil Contamination

We would note that no obvious visual or olfactory evidence of significant soil contamination was identified during the course of the site works (such as ashy soils, hydrocarbons or asbestos fragments, for example).

5.4 Water

The soils at the site were noted to become gradually damp with depth. Slight water seepages were observed within several of the pits from variable depths below 2.00m begl. Water was locally encountered within the window sampling boreholes, at a depth of approximately 3.00m begl.

5.5 Stability

The trial pits were generally stable during excavation and for the short period of time they were left open after completion of excavation.

The boreholes were not cased during their advancement, with the exception of WS1 which was cased to 1.00m begl as a precautionary measure.

5.6 Plates

A photographic record of the exploratory investigation was obtained during the intrusive works. Selected photographs of the intrusive works are presented on the Plates presented in Appendix X of this report (Plate Nos. 1 to 20).

5.7 Shear Vane Values

Shear vane testing was undertaken within the natural Silt and Clay soils within the trial pits.

Shear vane values obtained at depths in excess of 1.20m begl were taken ex-situ due to health and safety reasons.

A Chart showing the shear vane values in relation to depth recorded in the trial pits is provided below for information. Table 8 shows a summary on the shear vane values between specific depth ranges. Individual shear vane results are provided on the exploratory hole logs included in Appendix IX of this report.

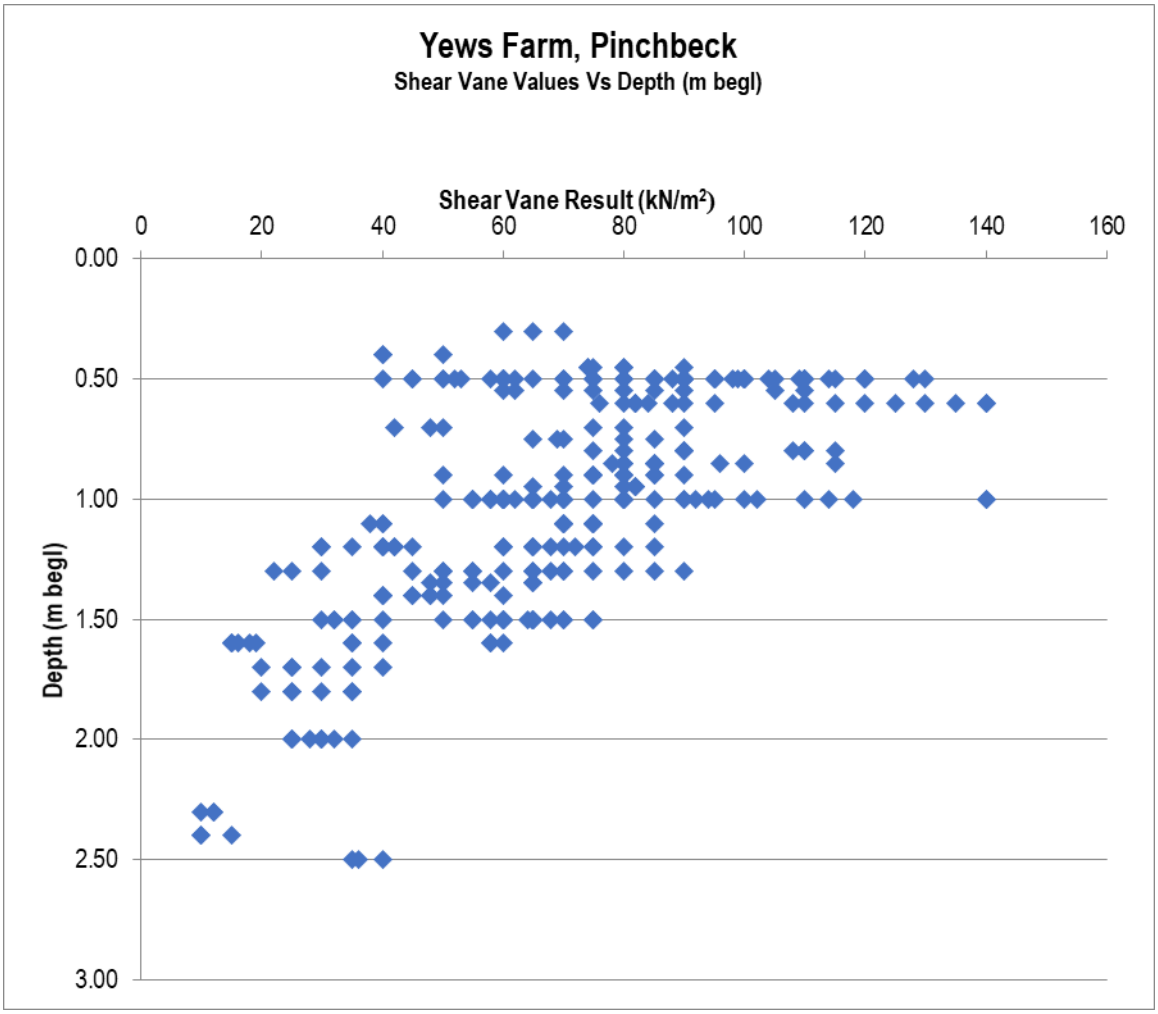


TABLE 8 – SUMMARY OF SHEAR VANE RESULTS			
Depth (m begl)	Minimum SV Reading (kN/m²)	Maximum SV Reading (kN/m²)	Average SV Reading (kN/m²)
0.00 – 0.50	40	130	68
0.50 – 1.00	42	140	82
1.00 – 1.50	22	90	57
1.50 – 2.00	15	60	30
2.00 – 2.50	10	40	20

5.8 Standard Penetration Test (SPT) Data

In order to establish a strength/depth profile of the strata beneath the site, SPT testing was undertaken in the boreholes.

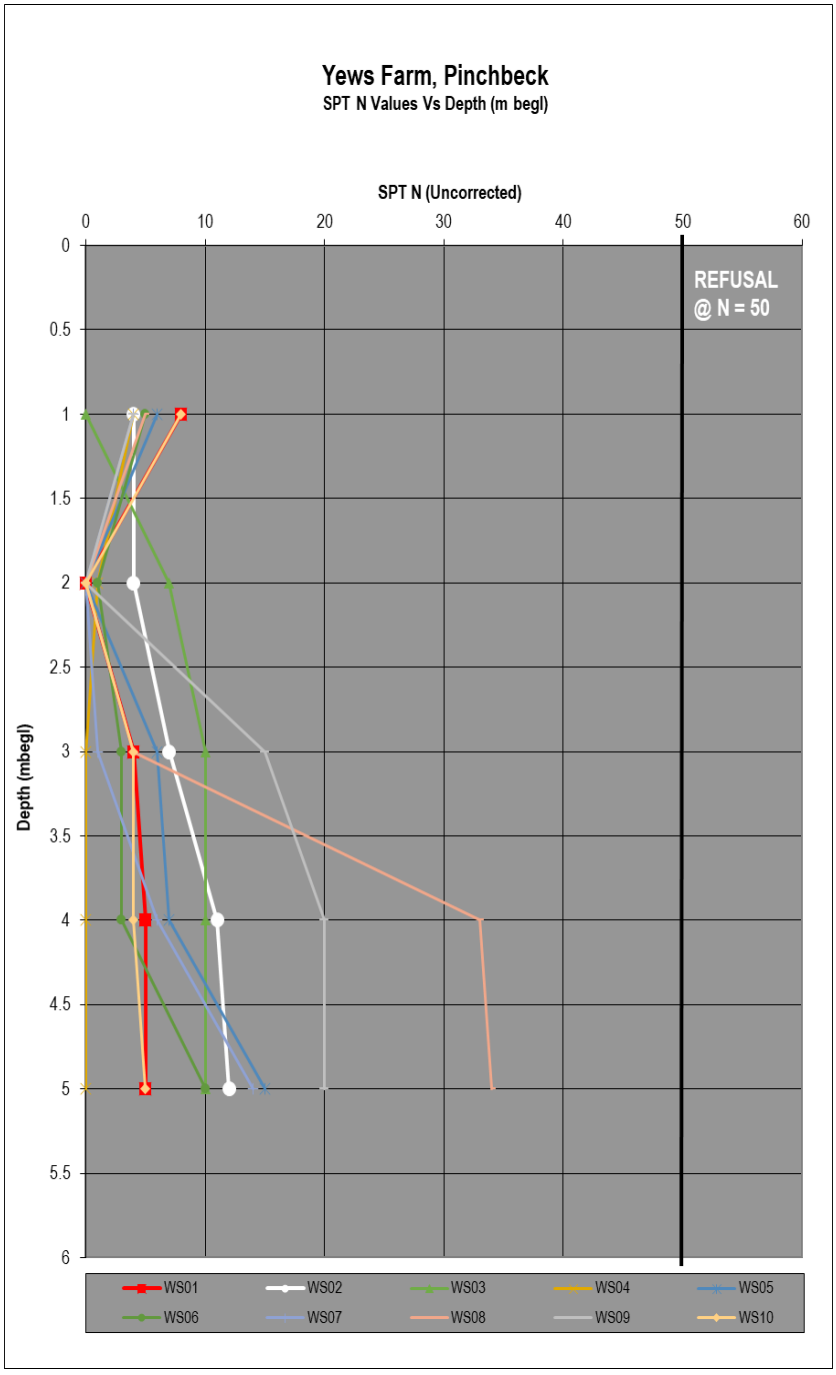
At a depth of 1.00m begl, uncorrected SPT 'N' values of between 4 and 8 were typically recorded within the Natural Strata. However, a value of 0 was recorded in WS3.

At a depth of 2.00m begl, the uncorrected SPT ‘N’ values ranged between 0 and 7.

At a depth of 3.00m begl, the uncorrected SPT ‘N’ values ranged between 1 and 10. However, a value of 0 was recorded in WS4.

At depths of 4.00m and 5.00m begl, the uncorrected SPT ‘N’ values ranged between 3 and 34. However, values of 0 were recorded in WS4.

An SPT Vs Depth Chart of the data obtained from the boreholes advanced at the site is shown on the chart below.



6.0 LABORATORY TESTING & CONTAMINATION ASSESSMENT

6.1 Introduction

As part of our works a suite of geotechnical laboratory soils testing has been undertaken, which comprised the following:

- 14No. Plasticity Index tests.
- 4No. Particle Size Distribution tests.
- 12No. Water soluble sulphate tests.
- 28No. pH tests.
- 4No. Remoulded Soaked CBR tests.

In addition, environmental soil testing was carried out on visually representative samples recovered from the exploratory holes. The testing strategy was based on the land use assessment and preliminary CSM derived by the desk study works, and was considered sufficient to enable an assessment of the chemical status of the soils at the site. The following testing has been undertaken as part of our works:

- 20No. Contamination suites (including metals, speciated Polycyclic Aromatic Hydrocarbons and Total Organic Carbon).
- 8No. Combined pesticide screens - Organochlorine & Organophosphate (OCP & OPP).

All laboratory soil test results are included in Appendix XI.

6.2 Geotechnical Soil Test Results

Water Soluble Sulphate/pH

Water soluble sulphate testing was undertaken on 12No. samples of the Natural Strata obtained during the site works. The testing revealed water soluble sulphate concentrations of between 10mg/l SO_4 and 149mg/l SO_4 within the samples analysed. The pH values of the samples of soils analysed (excluding topsoil) ranged between 6.97 and 8.46.

In accordance with the Building Research Establishment publication Special Digest 1 '*Concrete in Aggressive Ground*' (2005) the mean of the highest 20% of the sulphate results should be used to indicate the Design Sulphate Class (i.e. 79mg/l SO_4), together with the mean of the 20% lowest of the pH values (7.71).

Therefore, in accordance with Special Digest 1:2005 the site falls into Design Sulfate Class DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1. This classification has been made based on the assumption of a natural ground location with potentially mobile groundwater conditions beneath the site.

Plasticity Index Tests

A total of 14No. Plasticity Index tests have been undertaken on selected samples of the visually cohesive near surface Natural Strata obtained during the site works (i.e. Clay and Silt). In accordance with NHBC standards Chapter 4.2 *'Building Near Trees'* and BRE Digest 240 '*Low-rise buildings on shrinkable clay soils: Part 1*' (1993) the reported PI values may be modified based on the portion of the sample passing the 425μm sieve.

The result of the PI analysis is summarised in Table 9.

TABLE 9 – SUMMARY OF PLASTICITY INDEX (PI) DATA				
Sample Ref.	Reported PI Value (%)	Portion <425μm (%)	Modified PI Value (%)	Volume Change Potential
TP1, 1.00m (CLAY)	27	100	27	Medium
TP3, 0.50m (SILT)	23	100	23	Medium
TP5, 0.45m (CLAY)	23	100	23	Medium
TP12, 0.60m (CLAY)	43	96	41	High
TP15, 0.50m (SILT)	12	100	12	Low
TP18, 1.10m (CLAY)	18	100	18	Low
TP20, 1.40m (CLAY)	17	100	17	Low
TP23, 0.55m (SILT)	25	100	25	Medium
TP25, 1.20m (SILT)	13	100	13	Low
TP31, 0.80m (CLAY)	18	100	18	Low
WS5, 1.50m (CLAY)	31	100	31	Medium
WS7, 0.75m (CLAY)	21	100	21	Medium
WS8, 1.00m (CLAY)	39	98	38	Medium
WS9, 0.50m (CLAY)	16	100	16	Low

The testing has revealed that the soils analysed may be generally classified as of low to medium volume change potential. The result from TP12 (0.60m) appears to be an anomaly when compared to the data set obtained from similar depths within similar soil types. Soils of a medium volume change potential should therefore be assumed for design purposes.

Particle Size Distribution (PSD) Tests

PSD analysis was undertaken on four samples of the visually cohesive soils (i.e. Silt and Clay) obtained during the site works. The testing revealed a Silt/Clay content of >90% in all four samples analysed, which confirms the visual description of the soils.

Remoulded Soaked California Bearing Ratio (CBR) Testing

Remoulded soaked California Bearing Ratio testing was undertaken on 4No. samples of shallow Natural Strata across the site. The results of the recompacted CBR testing are summarised in Table 10 below. CBR values for the top and bottom of the remoulded soaked sample are recorded. The approximate locations of the CBR samples are shown on the plan presented in Appendix XII (Figure No. D39032/05).

TABLE 10 – SUMMARY OF LABORATORY CBR TEST RESULTS				
Sample Ref.	Depth (m begl)	Initial Moisture Content (%)	CBR Value Sample Top (%)	CBR Value Sample Bottom (%)
WS1 (CLAY)	0.50-1.00	19	1.0	0.9
TP4 (CLAY / SILT)	0.35-0.85	22	4.3	4.7
TP11 (CLAY / SILT)	0.30-0.80	25	1.9	1.6
TP24 (CLAY / SAND)	0.30-0.80	26	1.0	1.0

6.3 Contamination Assessment Rationale

We understand that it is proposed to develop the site with low-rise residential properties incorporating private gardens covering Phases 1 to 4. It is also understood that current development proposals includes an area of Public Open Space (POS) in the western portion (Phase 5) of the site.

6.3.1 Assessment Methodology

In order to undertake a Generic Quantitative Risk Assessment (GQRA) we have adopted the Suitable for Use Levels (S4ULs) published by LQM/CIEH in their publication referenced: Nathanail, C.P., McCaffrey, C. Gillett, A.G., Ogden, R.C. and Nathanail, J.F, 2015. '*The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham. All rights reserved.*' In the absence of an S4UL screening value, we have made reference to the Category 4 Screening Levels (C4SLs) published by DEFRA.

In consideration of the available generic land uses utilised in the derivation of the adopted screening criteria, we have adopted a residential end-use with plant uptake scenario for the purposes of our assessments.

For assessment purposes, we have adopted a policy whereby determinands within the dataset are individually compared to the relevant screening value (i.e. individual S4ULs). Where determinands within the dataset are less than the appropriate screening value, the determinand is considered to be present at an acceptable concentration and no further assessment is required. Additional comment, statistical assessment or further Detailed Quantitative Risk Assessment (DQRA) may be provided where elevated values are revealed.

6.3.2 Selection of Soil Organic Matter (SOM) Content

The SOM content and soil type are used to provide an assessment of the applicability of the screening values adopted (the S4UL values are typically based upon SOM of 1%, 2.5% and 6%, as applicable, with all metals derived utilising 6% SOM as standard).

Where available at Tier 1 level, determinands have in the first instance been compared to screening values adopting a conservative SOM of 1%.

Where the determinand exceeds the relevant screening value at 1% SOM, a site-specific SOM may be adopted as appropriate to derive more site-specific screening values and the dataset reassessed.

6.4 Sampling Strategy

The sampling strategy for the site was primarily to retrieve visually representative soil samples from a selection of locations that provide an initial coverage across the entire site area (where access allowed). The sampling strategy was based on a review of the historical, geological and environmental information obtained from the Desk Study enquiries and the current and proposed site setting together with and the ground conditions encountered during our Phase II exploratory works.

No specific areas of potential concern were identified at the site with respect to ground contamination other than the potential localised area of Made Ground (i.e. associated with the infilled drain) and the off-site former landfill to the south. Exploratory holes were therefore advanced to target these specific features and also to provide general site coverage, taking account the access restrictions and the presence of known buried services.

Table 11 summarises the reasoning behind the exploratory hole positions.

TABLE 11 – REASONING FOR EXPLORATORY HOLE LOCATION	
Exploratory Hole Reference	Reasoning Behind Location
TP1 – TP38	General site coverage avoiding known utilities within the proposed developable areas.
WS4, WS4, TP14, TP16 & TP20	Targeted to the infilled drain.
WS1 – WS5	General site coverage for the purposes of installing ground gas monitoring points. WS3 and WS4 targeted to the infilled drain and WS2 targeted to the off-site former landfill to the south.
WS6 – WS10	General site coverage avoiding known utilities (not accessible with the excavator) within the proposed developable areas.
HA1 – HA6	General site coverage avoiding known utilities in the area of proposed POS.
Key TP – Trial Pit WS – Window Sampling Borehole HA – Hand Auger Hole	

The ground conditions encountered during our Phase II works revealed the presence of two distinct types of material, i) Disturbed Topsoil and ii) the underlying Natural Strata.

Representative samples of these soil types were obtained during our Phase II works and subjected to chemical analysis for a suite of contaminants deemed appropriate based on the findings of the Desk Study and the ground conditions encountered during the intrusive investigation. It is noted that the suite of contaminants detailed in Section 4.6 were considered to remain applicable as an initial chemical screen of the encountered soils following completion of the site investigation works.

6.5 Contamination Analysis

Contamination tests were undertaken on visually representative samples of the natural Topsoil (10No.) and underlying Natural Strata (10No.) obtained from the site during our works.

In addition, eight samples of the topsoil across the site were subjected to pesticide analysis.

For initial assessment purposes, we have collated the results into two datasets, for individual comparison of the reported determinand concentrations against appropriate Tier 1 GACs, namely topsoil and the underlying undisturbed Natural Strata.

Please note that screening values have only been used for determinands where they are present at concentrations in excess of the LOD on at least one occasion.

6.6 Contamination Soil Test Results

6.6.1 Topsoil

The contamination assessment for the natural Topsoil at the site is summarised in Table 12.

TABLE 12 – SUMMARY OF TIER 1 GAC ASSESSMENT
(TOPSOIL - RESIDENTIAL WITH PLANT UPTAKE END-USE)

Contaminants – Potentially Harmful to Human Health	No. of Samples Tested	Concentration Range (mg/kg)	Tier 1 GAC (mg/kg)	Tier 1 GAC Exceeded (Yes/No)
Metals				
Arsenic	10	3 – 8	37 S4UL	No
Cadmium	10	0.6 – 0.9	11 S4UL	No
Chromium III	10	18 – 31	910 S4UL	No
Copper	10	9 – 13	2400 S4UL	No
Lead	10	11 – 31	200 C4SL	No
Nickel	10	13 – 22	130 S4UL	No
Selenium	10	<1 – 1	250 S4UL	No

Key
S4UL – CIEH/LQM Suitable 4 Use Levels (2015). Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3026. All rights reserved.
C4SL – value for Lead taken from DEFRA publication SP1010 and based on a residential (with home-grown produce) end-use.

All of the determinands assessed for the Topsoil were present at individual concentrations below the Limit of Detection of the method of analysis adopted by the laboratory or below the appropriate Tier 1 GAC based on a residential with plant uptake end-use.

6.6.3 Natural Strata

The contamination assessment for the Natural Strata at the site is summarised in Table 13.

TABLE 13 – SUMMARY OF TIER 1 GAC ASSESSMENT
(NATURAL STRATA - RESIDENTIAL WITH PLANT UPTAKE END-USE)

Contaminants – Potentially Harmful to Human Health	No. of Samples Tested	Concentration Range (mg/kg)	Tier 1 GAC (mg/kg)	Tier 1 GAC Exceeded (Yes/No)
Metals				
Arsenic	10	3 – 12	37 S4UL	No
Cadmium	10	<0.5 – 18	11 S4UL	No
Chromium III	10	<0.17 – 42	910 S4UL	No
Copper	10	4 – 26	2400 S4UL	No
Lead	10	6 – 26	200 C4SL	No
Nickel	10	10 – 41	130 S4UL	No
Selenium	10	<1 – 1	250 S4UL	No
Zinc	10	36 – 55	3700 S4UL	No
PAH				
Fluoranthene	10	<0.1 – 0.1	280 S4UL	No
Pyrene	10	<0.1 – 0.1	620 S4UL	No

Key
S4UL – CIEH/LQM Suitable 4 Use Levels (2015). Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3026. All rights reserved.
C4SL – value for Lead taken from DEFRA publication SP1010 and based on a residential (with home-grown produce) end-use.

All of the determinands assessed for Natural Strata were present at individual concentrations below the Limit of Detection of the method of analysis adopted by the laboratory or below the appropriate Tier 1 GAC based on a residential with plant uptake end-use.

6.7 Pesticides

8No. samples of the Topsoil from across the site were tested for a suite of pesticides. The results typically revealed individual concentrations below the Limit of Detection of the method of analysis adopted by the laboratory (0.01mg/kg, 0.10mg/kg or 0.50mg/kg). However, concentrations of Pendimethalin (0.01mg/kg, 0.04mg/kg and 0.37mg/kg) were detected within three samples (TP17, TP25 and TP3, respectively).

We would note that there are presently no publicly available generic screening criteria for soils for Pendimethalin specific to the UK setting. We have therefore reviewed other sources of screening criteria for comparison purposes.

USEPA (United States Environmental Protection Agency) have co-operated to prepare Screening Levels (SLs) '*Regional Screening Level (RSL) Resident Soil Table November 2017*' for use within Superfund sites (i.e. contaminated land). USEPA have provided a screening level of 19000mg/kg for pendimethalin. The pesticide concentrations recorded within topsoil sample at the site do not exceed this values.

6.8 Contamination Assessment Summary

Human Health

Contamination testing was carried out on selected samples of the Topsoil and the underlying Natural Strata. On the basis of the chemical contamination assessment undertaken, the soils may be considered to be uncontaminated for the proposed residential with plant uptake end-use (i.e. in relation to human health).

We would additionally note that no visual or olfactory evidence of significant contamination was identified during the course of the exploratory investigation works.

Controlled Waters

Given the low contaminant concentrations revealed by the testing, together with the generally low groundwater sensitivity of the area, there are considered to be no specific risks posed to Controlled Waters by the findings of the laboratory analysis undertaken.

7.0 GROUND GAS & WATER LEVEL MONITORING RESULTS

7.1 Introduction

Based on the potential presence of on and off-site sources of potentially harmful ground gas, monitoring points were installed in selected completed boreholes to facilitate an initial programme of monitoring (i.e. for methane and carbon dioxide).

7.2 Monitoring Installations

Upon completion, five of the window sampling boreholes (WS1 to WS5) were installed with combined ground gas and water monitoring standpipes to a depth of 5.00m begl to facilitate an initial programme of monitoring.

The ground gas and water monitoring data obtained from the site is presented in Appendix XIII of this report.

7.3 Results of the Ground Gas Monitoring

A total of six ground gas and water monitoring visits have been undertaken at the site over a six week period. The ground gas monitoring results are summarised in Table 14.

TABLE 14 – SUMMARY OF GROUND GAS MONITORING DATA

Parameter	Minimum	Maximum
Methane (v/v)	0.0	0.0
Carbon Dioxide (v/v)	0.0	2.8
Oxygen (v/v)	15.6	21.6
Peak Flow (L/h)	0.0	0.0
Steady Flow (L/h)	0.0	0.0

KEY
v/v - % by volume
L/h – litres/hour

Periods of rapidly falling atmospheric pressure are considered to be the optimum barometric conditions for gas emissions from the ground. The majority of the gas monitoring visits were carried out during periods of falling atmospheric pressure.

The atmospheric pressure trends are summarised below:

- 30th November – Fall of 4mb
- 7th December – Fall of 3mb
- 14th December – Fall of 4mb
- 22nd December – Rise of 11mb
- 5th January – Rise of 1mb
- 12th January – Fall of 2mb

The atmospheric pressure trends noted during the monitoring period do not appear to have affected the ground gas flow rates recorded during the monitoring period. No variations in flow rates were noted during the monitoring carried out, as no flow rates were recorded on any of the monitoring visits, including the visit carried out following a period of rapidly falling atmospheric pressure. The highest recorded carbon dioxide concentration of 2.8% by volume was detected when the atmospheric pressure fell by 4mb in the 24 hours prior to monitoring on 30th November 2020.

Water was recorded during the course of the monitoring programme, at depths of between 0.52m and 1.54m begl. It is likely that the water within the monitoring standpipes recorded during the monitoring programme represents water as a result of surface water run-off following rainfall rather than a true groundwater level.

7.4 Appropriate Guidance

7.4.1 British Standard & CIRIA

The results of the gas monitoring have been reviewed with reference to the following documentation:

- British Standard BS 8485 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*' (2019).
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).
- CIRIA Report C735 '*Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*' (2014).

7.4.2 Gas Screening Value Calculation

8485:2015+A1:2019 and CIRIA Report C665 recommend a risk-based methodology to ground gas assessment, the first step of which includes the calculation of a site-specific Gas Screening Value (GSV). The GSV of a particular ground gas regime equates to:

- GSV (l/h) = maximum borehole flow rate (l/h) x (maximum gas concentration/100).

The GSV should be calculated for both Methane and Carbon Dioxide (where appropriate) to determine a site-specific Characteristic Situation for each gas. The higher the calculated GSV, the greater the risk posed by the presence of ground gas. The CIRIA guidance document notes that '*…the GSV is a guideline value and not an absolute threshold*'.

7.4.3 Site Classification

The next step in the assessment process is determining the sites classification. Table 2 of 8485:2015+A1:2019+A1:2019 (reproduced below) presents six Characteristic Situations (CS) to assist in the classification of the site, based on the calculated GSV for Methane and Carbon Dioxide.

Table 2 — *CS by site characteristic GSV*

CS	Hazard potential	Site characteristic GSV [A)] L/h	Additional factors
CS1	Very low	<0.07	Typically <1% methane concentration and <5% carbon dioxide concentration (otherwise consider an increase to CS2)
CS2	Low	0.07 to <0.7	Typical measured flow rate <70 L/h (otherwise consider an increase to CS3)
CS3	Moderate	0.7 to <3.5	–
CS4	Moderate to high	3.5 to <15	–
CS5	High	15 to <70	–
CS6	Very high	>70	–

A) The figures used in this column are empirical.

NOTE The CS is equivalent to the characteristic GSV in CIRIA C665 [6].

7.4.4 Proposed Building Type

In accordance with 8485:2015+A1:2019+A1:2019, the CS classification for the site should be considered in conjunction with the proposed Building Type to determine the appropriate level of ground gas protection measures that should be installed to mitigate the risk posed by ground gases.

8485:2015+A1:2019+A1:2019 notes '*The Building Type is determined based the proposed construction and use of the building, together with the control of future structural changes to the building and its maintenance (the building's management) should be assessed, since potential risks posed by ground gases are strongly influenced by these factors*'.

Subject to the development proposals, each building may be categorised as a whole, or for each different part of the building.

The Building Types presented in Table 3 of 8485:2015+A1:2019+A1:2019, are reproduced below.

Table 3 — *Building types*

	Type A	Type B	Type C	Type D
Ownership	Private	Private or commercial/ public, possible multiple	Commercial/ public	Commercial/ industrial
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full
Room sizes	Small	Small/ medium	Small to large	Large industrial/ retail park style

- **Type A building**: private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
- **Type B building**: private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels.
- **Type C building**: commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).
- **Type D building**: industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses. (Small rooms within these style buildings should be separately categorized as Type B or Type C).

NOTE 2 Type A buildings are those where the risk of failure of the gas protection measures is likely to be most significant to the safety of the occupants and Type D buildings are those where this same risk is likely to be least significant.

7.4.5 Gas Protection Score (Number of Points to be Achieved)

Table 4 of 8485:2015+A1:2019+A1:2019, reproduced below, should be used to derive the minimum level of gas protection applicable to the Building Type, based on the CS determined from the calculated GSV. The Gas protection Score in Table 4 below is used to determine the level and type of protection measures used.

Table 4 — *Gas protection score by CS and type of building*

CS	Minimum gas protection score (points)			
	High risk		Medium risk	Low risk
	Type A building	Type B building	Type C building	Type D building
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5 [A)]	5.5 [A)]	4.5	3.5
5	— [B)]	[A1] 6 [A1] [A)]	5.5	4.5
6	— [B)]	— [B)]	[A1] — [B)] [A1]	[A1] 6 [A1]

[A)] Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.

[B)] The gas hazard is too high for this empirical method to be used to define the gas protection measures.

7.4.6 Methods of Achieving Gas Protection Scores

The appropriate level of precautions, to be designed in accordance with the point scoring system of 8485:2015+A1:2019, should therefore be determined for the specific type of developments based on the GSV and CS of the site. These may include a combination of two or more of the following three types of protection measures, which could be used to achieve the required score:

- The structural barrier of the floor slab, or of the basement slab and walls if a basement is present;
- Ventilation measures; and
- Gas resistant membrane which may include an element of verification and potentially integrity testing.

Verification and integrity testing should be undertaken in accordance with CIRIA report C735 '*Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*' (2014) and would be detailed in a Remediation Method Statement report in advance of construction which should be agreed with the Local Planning Authority.

The points achieved for each element of the ground gas precautions are summarised in Tables 5, 6 and 7 of the British Standard. These tables are reproduced below.

Table 5 — *Gas protection scores for the structural barrier*

Floor and substructure design (see Annex A)	Score [A]
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations	1 or 1.5 [B]
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing [C] [D]	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing [C] [D]	2.5

[A] The scores are conditional on breaches of floor slabs, etc., being effectively sealed.

[B] To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see **A.2.2.2**).

[C] The score is conditional on the waterproofing being provided by a suitable structural barrier with the design and detailing of the walls and floor meeting the requirements for Type B protection. The score cannot be assigned for Type A (waterproof membrane) or Type C (drained cavity wall).

[D] If a membrane is installed beneath and around the basement to provide Type A waterproofing (BS 8102:2009), it can be assigned a gas protection score in accordance with Table 7, if it meets all the criteria for a gas resistant membrane in that table.

Table 6 — *Gas protection scores for ventilation protection measures*

Protection element/system	Score	Comments
(a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	0.5	Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is zero.

Table 6 *(continued)*

Protection element/system	Score	Comments
(b) Passive sub floor dispersal layer:	2.5	Performance criteria for methane and carbon dioxide are shown in Figure B.6 and Figure B.7, respectively.
Very good performance:	1.5	
Good performance:		
Media used to provide the dispersal layer are: • Clear void • Polystyrene void former blanket • Geocomposite void former blanket • No-fines gravel layer with gas drains • No-fines gravel layer		The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B. Passive ventilation should be designed to meet at least "good performance", see Annex B.
(c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance", as described in Annex B.
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to *Buildings Regulations 2000, Approved Document F* [9].

Table 7 — *Gas protection score for the gas resistant membrane*

Protection element/system	Score	Comments
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious ⟨A1⟩ , both in the sheet material [A)] and in the sealing of sheets and sealing around sheet penetrations, to prevent any significant passage of methane and/or carbon dioxide through the membrane; ⟨A1⟩ • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • ⟨A1⟩ *Text deleted* ⟨A1⟩ • sufficiently strong ⟨A1⟩ [B)] ⟨A1⟩ to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); ⟨A1⟩ and to withstand in-service stresses (e.g. settlement if placed below a floor slab); ⟨A1⟩ • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • verified in accordance with CIRIA C735 [N1].	2	The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. ⟨A1⟩ *Text deleted* ⟨A1⟩ If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.

[A)] ⟨A1⟩ A membrane with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheets and joints (tested in accordance with BS ISO 15105-1:2007 manometric method) is regarded as sufficiently impervious.

[B)] For example, reinforced LDPE (virgin polymer) membranes having a minimum mass per unit area of 370 g/m² and not significantly less than 0.4 mm thickness between the reinforcement scrim (tested in accordance with Procedure D (2 mm diameter tip) of BS EN ISO 9863-1:2016) installed above floor slabs are considered sufficiently strong to meet the performance criteria (see also **C.3**). Thicker and more robust membranes or an additional membrane protection layer should be installed directly beneath cast-in-situ floor slabs. ⟨A1⟩

7.5 Ground Gas Analysis

7.5.1 Gas Screening Value & Site Classification

The ground gas monitoring undertaken to date has identified no methane and a maximum carbon dioxide concentrations of 2.8% v/v by volume. Measureable steady flow rates were not recorded during the monitoring visits. In the absence of a measurable steady flow rate, the limit of detection of the gas monitoring instrument (0.1 l/h) should be utilised. The atmospheric pressure trends noted during the monitoring period do not appear to have affected the low ground gas concentrations recorded.

The GSV for carbon dioxide at the site may be calculated as follows:

- 0.1 x (2.8/100) = 0.0028 l/h

Therefore, with a maximum GSV of 0.0028 l/h, a carbon dioxide concentration of 2.8% by volume, no methane concentrations and no measurable steady flow rate, the site may be classified as '**CS1**' in accordance with Table 2 of BS 8485 and based on the visits undertaken.

7.5.2 Building Type

We understand that it is proposed to construct low-rise residential properties at the site. In accordance with Table 3 of BS 8485, **Building Type A** is considered to be the most appropriate classification.

7.5.3 Gas Protection Score

On the basis of Characteristic Situation (CS1) and the development proposals with structures that may be designated as Building Type A and in accordance with Table 4 of BS 8485:2015+A1:2019, the minimum gas protection score for the site is 0 points.

7.5.4 Comments

The results of the gas monitoring carried out indicate that no ground gas precautions would be required for the site based on the gas protection score of zero in accordance with BS 8485:2015+A1:2019.

8.0 REVISED CONCEPTUAL SITE MODEL

8.1 Introduction

In accordance with the approach detailed within Section 4.0, the Conceptual Site Model (CSM) for the site should be refined following acquisition and collection of additional data following completion of the site investigation works.

Our revised assessment following the acquisition and collection of information from the site investigation works is provided in Table 15.

TABLE 15 – REVISED RISK ASSESSMENT SUMMARY TABLE PHASE II EXPLORATORY INVESTIGATION						
Potential Contaminant Source [C]	Potential Pathway(s) [P]	Potential Receptor [R]	Probability of CPR Linkage	Consequence of CPR Linkage	Risk Level	Comments / Justification
Near Surface Soils	Direct contact, ingestion or inhalation of fugitive dust	End users	Unlikely	Medium	Low	Made Ground was not encountered at the site. The soils may be regarded as uncontaminated, based on a residential with plant uptake end-use and the testing undertaken.
	Plant uptake	End users	Unlikely	Medium	Low	Made Ground was not encountered at the site. The soils may be regarded as uncontaminated, based on a residential with plant uptake end-use and the testing undertaken.
	Vertical and lateral migration	Neighbouring properties	Unlikely	Mild	Negligible	Made Ground was not encountered at the site. The soils may be regarded as uncontaminated, based on a residential with plant uptake end-use and the testing undertaken. No sources of potential mobile hydrocarbon contamination have been identified and there was no obvious visual or olfactory evidence of any significant contamination (i.e. hydrocarbon impacted soils, for example).
	Leaching of Contaminants through unsaturated zone and/or vertical and lateral migration	Controlled Waters	Unlikely	Mild	Negligible	Made Ground was not encountered at the site. The soils may be regarded as uncontaminated, based on a residential with plant uptake end-use and the testing undertaken. No sources of potential mobile hydrocarbon contamination have been identified and there was no obvious visual or olfactory evidence of any significant contamination (i.e. hydrocarbon impacted soils, for example).
	Direct contact or contact with vapours	Plastic buildings products (i.e. water supply pipes) and buried concrete	Unlikely	Mild	Negligible	Made Ground was not encountered at the site. No sources of potentially mobile hydrocarbon contamination have been identified and there was no obvious visual or olfactory evidence of any significant contamination (i.e. hydrocarbon impacted soils, for example). Design Class DS-1/ACEC Class AC-1. (BRE Spec. Digest 1:2005).
	Vertical and lateral migration of ground gases to indoor air	End users of new buildings (asphyxiation) or new buildings (damage via explosion)	Unlikely	Medium	Low	Based on the ground gas monitoring undertaken, the site may be classified as Characteristic Situation 'CS1' in accordance with BS8485:2015+A1:2019.
Off-Site Infilled Features	Vertical and lateral migration of ground gases to indoor air	End users of new buildings (asphyxiation) or new buildings (damage via explosion)	Unlikely	Medium	Low	Based on the ground gas monitoring undertaken, the site may be classified as Characteristic Situation 'CS1' in accordance with BS8485:2015+A1:2019.

9.0 CONCLUSIONS & RECOMMENDATIONS

9.1 Site Summary

At the time of our works (November 2020), the site essentially comprised three undeveloped, sensibly level fields. Based on the reviewed historical information, the site has remained unchanged according to the earliest available historical maps of the 1880s.

The site is indicated to be underlain by superficial drift comprising Tidal Flat Deposits. The underlying bedrock is indicated to comprise the Oxford Clay Formation.

9.2 Geotechnical Information

9.2.1 Ground Conditions

Made Ground was not encountered at the site.

Topsoil was encountered at the surface in all of the exploratory holes to depths of between 0.20m and 0.45m. The average thickness of the Topsoil across the proposed development areas (i.e. Phases 1 to 4) was 0.35m begl.

Beneath the Topsoil, the Natural Strata typically comprised firm or stiff sandy silty CLAY, which became softer with depth. The Clay was noted to be locally interbedded with firm sandy clayey SILT in the near surface horizons.

Underlying the Clay / Silt soils, loose to medium dense (locally medium dense to dense) silty SAND was encountered from depths of below 3.00m begl.

The soils are considered to be typically representative of Tidal Flat Deposits, which are indicated by geological publications to underlie the site.

9.2.2 Foundation Design

Foundations for the proposed development are likely to comprise Structural Engineer designed strip or raft foundations (to suit the loading characteristics of the proposed structures and incorporate mesh reinforcement, if considered appropriate).

The natural soils underlying the site at shallow depth, appear suitable to support a nett allowable ground bearing pressure of up to 75kN/m^2. This bearing pressure is considered appropriate due to the presence of underlying Tidal Flat Deposits, which have the potential to alter rapidly in character and geotechnical properties both laterally and vertically over relatively short distances and contain variable groundwater conditions/levels.

Based on laboratory test results, the soils may be considered to be of medium volume change potential for design purposes. Therefore, in all circumstances, foundations should be advanced to a minimum depth of 0.90m below existing or proposed ground level (whichever being the deeper) and founded within undisturbed suitably competent natural soils.

Should any potential localised Made Ground, disturbed ground or soft spots be encountered at founding depth, foundations will require further deepening to encounter underlying undisturbed suitably competent natural soils.

The use of a deeper founding solution (i.e. piles, for example) may need to be considered if there is a need to raise site levels and/or where excessive loads from buildings are present and shallow foundations are not deemed appropriate, subject to advice from a Structural Engineer.

We would note that the natural soils become gradually damp with depth. It is important to ensure that all foundation excavations are kept as shallow as possible to avoid potential decreased in soil strength from affecting foundation integrity.

The use of piles at the site would be subject to advice from a specialist piling contractor to confirm the depths of the piles and the most feasible and cost efficient type of pile to be used at the site. It would be necessary to undertake further intrusive works at the site involving cable percussive boreholes to assess the deeper ground conditions to assist with a piled foundation solution for the proposed development.

It should be noted that a significant number of archaeological trenches / excavations were present at the time of our site works within the proposed Phase 1 development area (see plan in Appendix II). It would be prudent to survey the locations and extent of these trenches / excavations and map them onto the proposed site layout when the development proposals have been finalised. It may be necessary to adopt localised deeper foundations within Phase 1 if any of the archaeological trenches / excavations coincide with the locations of proposed dwellings.

9.2.3 Floor Slab Design

Where strip foundations are considered appropriate, ground bearing floor slabs may be adopted at the site provided that there is less than 0.60m of suitably compacted geotechnically competent sub-slab fill beneath proposed slabs. Alternatively, a suspended slab may be adopted, which may be either cast in-situ or a pre-cast suspended floor with a clear ventilated void (i.e. beam and block).

9.2.4 Ground Gas Precautions

Based on the findings of the gas monitoring undertaken at the site, no ground gas precautions relating to carbon dioxide or methane are required.

9.2.5 Radon

No radon precautions are required at the site.

9.2.6 Building Near Trees

Foundation designs (including floor slabs) will need to be adjusted where building near existing, proposed or recently removed trees and hedgerows, in accordance with NHBC Standards Chapter 4.2 *'Building near trees'*. Soils of a medium volume change potential should be assumed for design purposes. It should be noted that there is a general absence of existing trees and / or hedgerows in close proximity to the site.

9.2.7 Water

The soils at the site were noted to be become gradually damp with depth. Slight water seepages were observed within several of the pits from variable depths below 2.00m begl. Water was locally encountered within the window sampling boreholes at a depth of approximately 3.00m begl.

Based on the ground conditions encountered during the intrusive works, foundation excavations are unlikely to require dewatering. However, deeper excavations (i.e. sewers, for example) may encounter water seepage, which should be controllable utilising minor sump pumping techniques, in the first instance.

Excavations may be susceptible to standing water following periods of wet weather. It should be noted that groundwater levels may vary due to seasonal or other effects. Excavations undertaken in the typically drier summer months may result in different conditions than those encountered during our works.

9.2.8 Excavations / Stability

The trial pits were generally stable during excavation and for the short period of time they were left open after completion of excavation. The assessment of excavations and provision of support will be the responsibility of the contractor on site.

The natural soils may be subject to deterioration and softening if excavations are left open and exposed to wet weather. Any softened soils should be removed from excavations prior to the pouring of concrete.

9.2.9 Sulphate Classification

In accordance with BRE Special Digest 1 (2005), the site falls into Design Sulphate Class DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1.

Therefore, an appropriate concrete mix should be adopted in accordance with BRE Special Digest 1 for all buried concrete in contact with the ground.

9.2.10 Coal Mining

No coal mining precautions or associated investigation works are required at the site.

9.2.11 California Bearing Ratios (CBRs)

The remoulded soaked CBR testing has revealed CBR values for the Natural Strata between 0.9% and 4.7%.

9.2.12 Surface Water Drainage

Based on the geology encountered during the intrusive works, soakaways are unlikely to be suitable at the site. Therefore, alternative drainage solutions should be considered for the site.

9.3 Environmental Considerations

9.3.1 Soil Contamination Assessment

Contamination testing was carried out on selected samples of the surface Topsoil and the underlying Natural Strata.

Human Health

On the basis of the chemical contamination assessment undertaken, the soils may be considered to be uncontaminated in the context of the proposed end-use (i.e. in relation to human health).

We would note that no obvious visual or olfactory evidence of significant soil contamination was identified during the course of the site works.

Controlled Waters

Given the low contaminant concentrations revealed by the testing, there are considered to be no specific risks posed to Controlled Waters by the findings of the laboratory analysis undertaken.

9.3.2 Remediation Proposals / Re-Use of Soils

No specific remediation works will be required other than the provision of existing topsoil in proposed gardens and any other areas of soft landscape to provide a suitable growing media for plants. It may be necessary to increase the thickness of topsoil around the root balls of trees to suit the proposed planting regime.

9.3.3 Gardens & Areas of Soft Landscape

The existing topsoil at the site is considered chemically suitable for re-use within the proposed development (based on laboratory testing). The physical suitability of these soils should be assessed and determined on site by the developer.

Should there be a requirement to import topsoil to the site (although unlikely), it will be necessary to test the topsoil at source to ensure it is suitably clean (prior to importation) in accordance with CLEA/generic guidance. The topsoil should also conform to BS3882: 2015 '*Specification for topsoil*', with respect to the presence of foreign objects, and ideally nutrient levels etc. The results of the chemical analysis on topsoil proposed for importation should be forwarded to the Local Authority (Environmental Health Officer) for approval (prior to importation).

9.3.4 Re-use of Existing Natural Strata

The Natural Strata may be regarded as suitable for re-use within proposed gardens or areas of soft landscape as subsoil (to raise levels, as appropriate) or for landscaping/capping on alternative developments (subject to regulatory approval and the production of any necessary plans or permits) where surplus arisings are generated from the site.

9.3.5 Off Site Disposal & Waste Acceptance Criteria Testing

If off-site disposal is required the chemical testing regime can be different to the chemical testing required to assess the suitability of the soils for retention on site and the risks to human health. Therefore, a separate contamination assessment may be required to include bespoke leachate analysis (i.e. Waste Acceptance Criteria [WAC] testing) to classify the soils for off-site disposal with testing criteria to assess whether the soil is hazardous, non-hazardous or inert waste. However, the existing chemical test data will assist this process.

If disposal is necessary then the environmental laboratory test results (included within Appendix XI) should be provided to several landfill operators for consideration and cost provision in the first instance, prior to the material being removed from the site.

9.4 General Considerations

9.4.1 Construction Workers

No contamination has been identified that requires specific PPE. However, it is recommended that construction personnel involved with direct contact with the soils at the site use appropriate PPE equipment (i.e. boots, gloves and overalls) together with hygiene facilities in accordance with general health and safety guidelines.

A copy of this report should be included in the site health and safety file, and site workers should be made fully aware of the sites setting.

9.4.2 Utilities

Prior to development of the site, we would recommend that a copy of this report is supplied to utility companies, and that their recommendations relating to appropriate supply pipes are adhered to.

9.4.3 Unforeseen Circumstances

Should any areas of potentially contaminated soil be encountered during site construction works we would recommend consultation with GeoDyne to ensure that our recommendations continue to apply. Any potentially contaminated soils should be left in-situ and subjected to further assessment, to potentially include further chemical testing and risk assessment.

The following procedure should be adhered to if any areas of previously unidentified suspected contamination are encountered during the development of the site:

i. Suspected contaminated material will remain in-situ.
ii. GeoDyne to be notified. We will then undertake a visual assessment of the possible contamination, followed by appropriate sampling/testing (as necessary).
iii. If necessary, contamination will then be treated or removed from site. All necessary remediation works should be validated by testing in accordance with an approved strategy, with the relevant Regulators informed accordingly.

9.4.4 Flood Risk

The desk study information has revealed the site to lie within an area identified as being at risk of flooding. It is recommended that advice be sought from a Drainage Consultant with respect to this matter.

9.4.5 Licenses, Permits, Registrations, Plans and Approvals

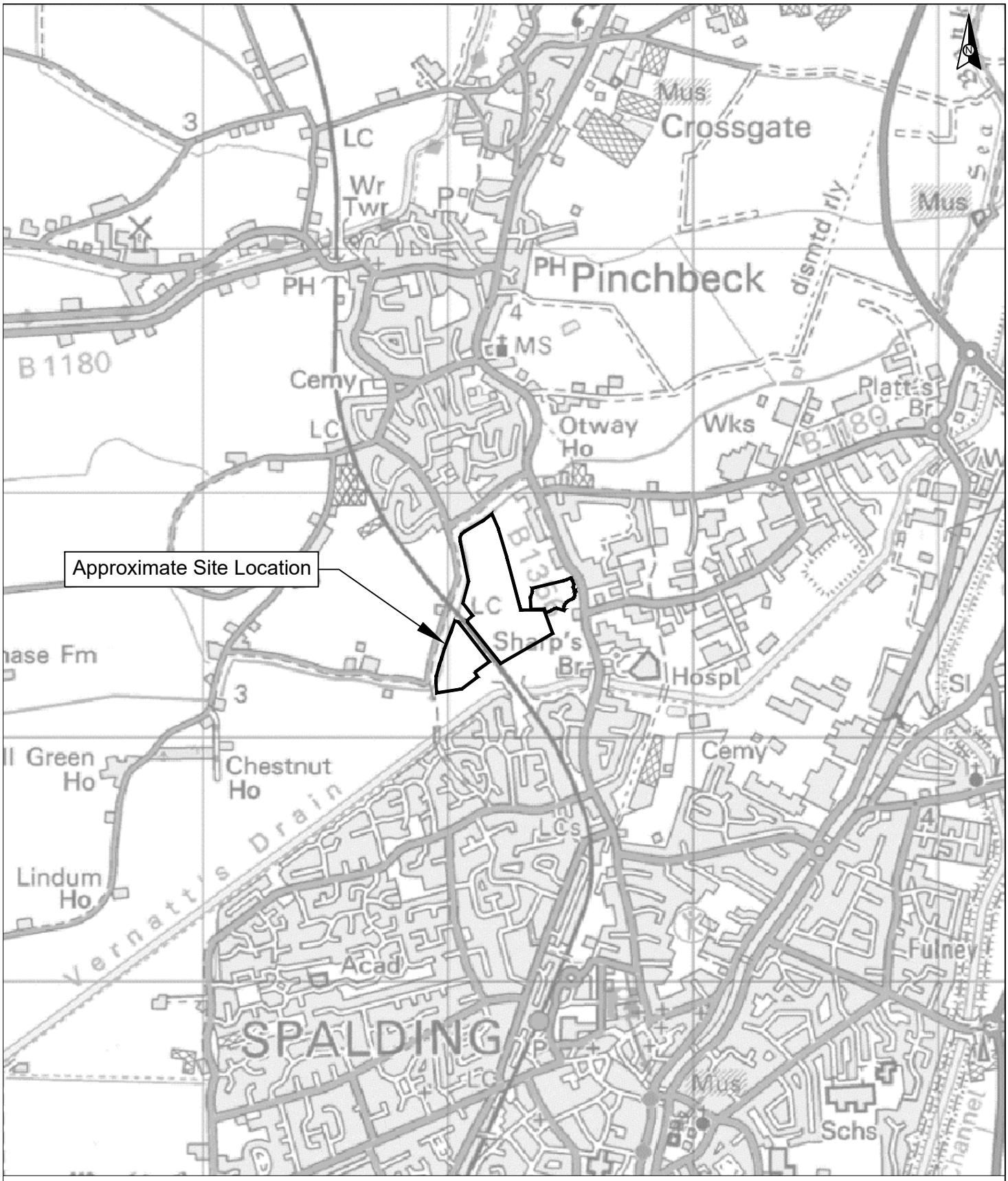
The Contractor/Developer is responsible for, and must ensure that, all necessary licenses, permits, plans, registrations and approvals are in place prior to commencing with the construction works at the site. These may include any Materials Management Plans (MMPs), Site Waste Management Plans (SWMPs) and/or Environmental Permits/Exemptions as necessary to enable the completion of the proposed works. Any MMP should be accompanied by a Qualified Person Declaration (QPD) and will require verification in due course.

9.4.6 Statutory Consultation

In accordance with normal planning requirements, we would recommend that a copy of our report is issued by the Client to the Local Authority (and NHBC or other Warranty Provider, if necessary) for review/comment and approval prior to commencing with the development of the site.

APPENDIX I

Site Location Plan
(Figure No. D39032/01)



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Project No.	D39032	Drawn By	GH
Client	Ashwood Homes	Checked By	PK
		Approved By	PK
Project	Yews Farm, Pinchbeck	Scale	NTS
		Date Drawn	05/01/2021
Title	Site Location Plan	Revision	
		Figure No.	D39032/01

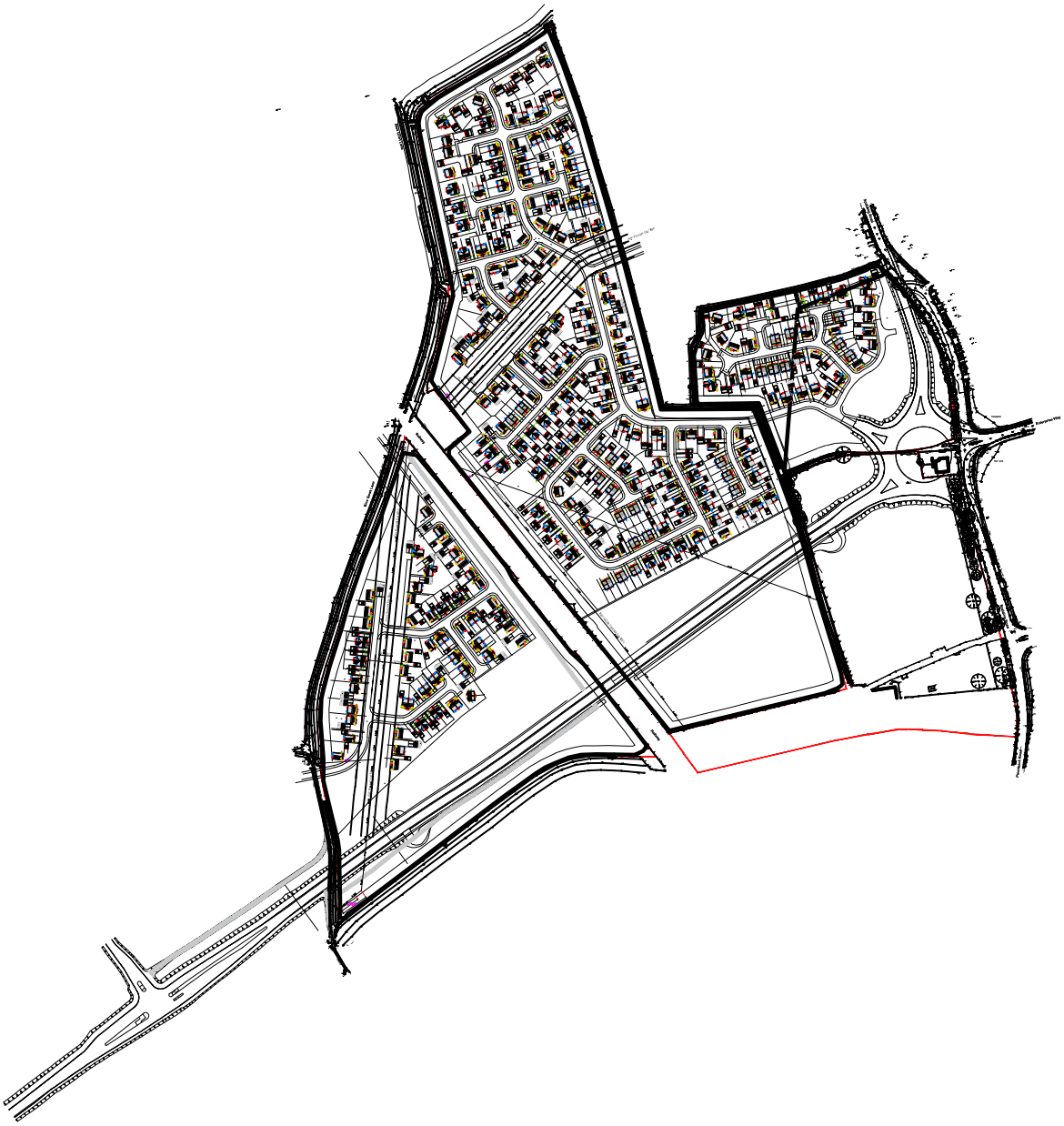
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APPENDIX II

Draft Development Plans



draft layout sep2020

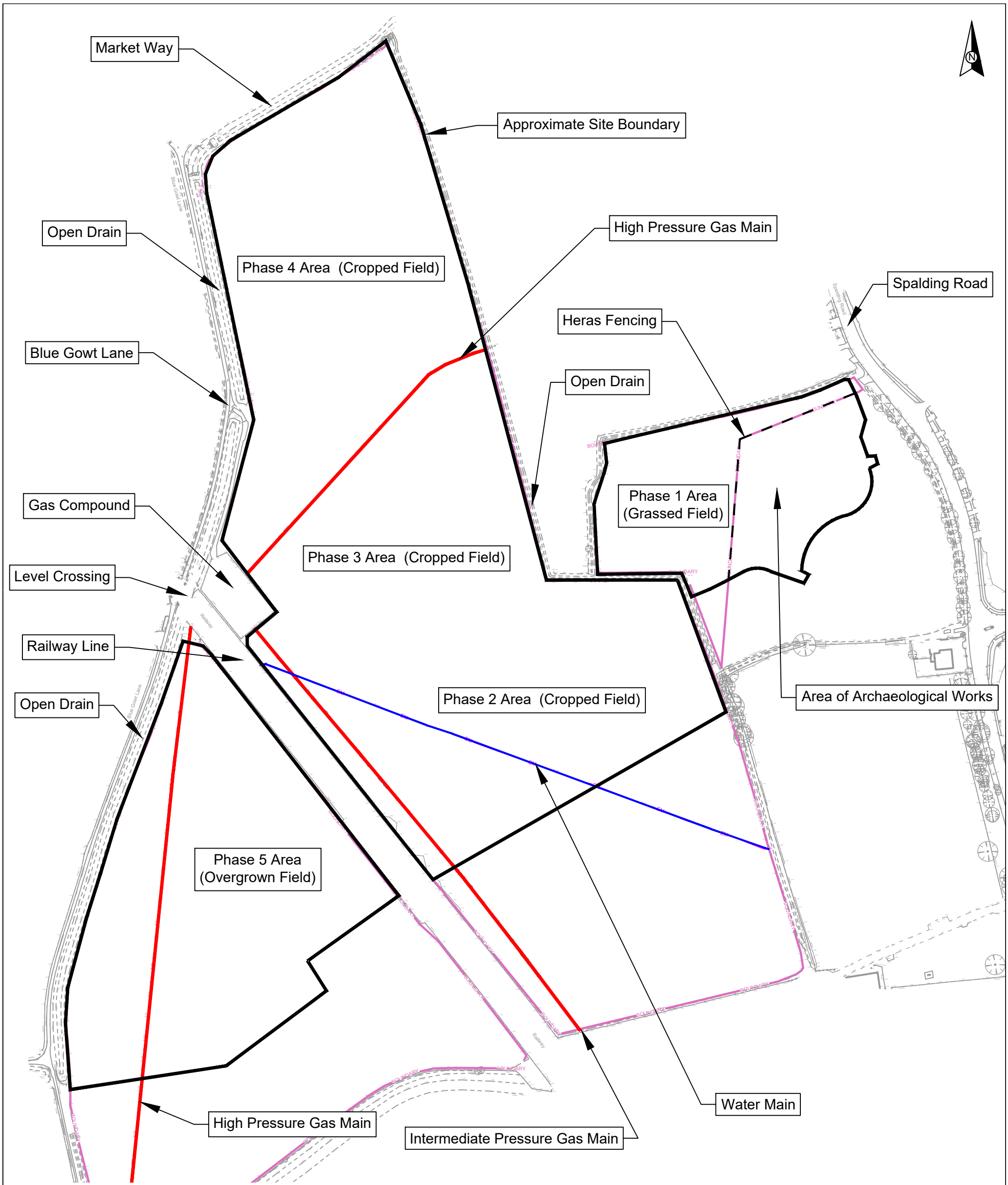
based on surveyed gas main routes

TOTAL DEVELOPABLE AREA
130185 SQM



APPENDIX III

Annotated Site Plan
(Figure No. D39032/02)



Drawing based on Utility Survey Report by Mantra Drawing No. 1036-100 Dated: 23/07/20. Used, edited and reproduced with permission of the Client.

Project No.	D39032	Drawn By	GH
Client	Ashwood Homes	Checked By	PK
		Approved By	PK
Project	Yews Farm, Pinchbeck	Scale	NTS
		Date Drawn	05/01/2021
Title	Annotated Site Plan	Revision	
		Figure No.	D39032/02

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APPENDIX IV

Site Plan Showing General Site Views
(Figure No. D39032/03)













Drawing based on Utility Survey Report by Mantra Drawing No. 1036-100 Dated: 23/07/20. Used, edited and reproduced with permission of the Client.

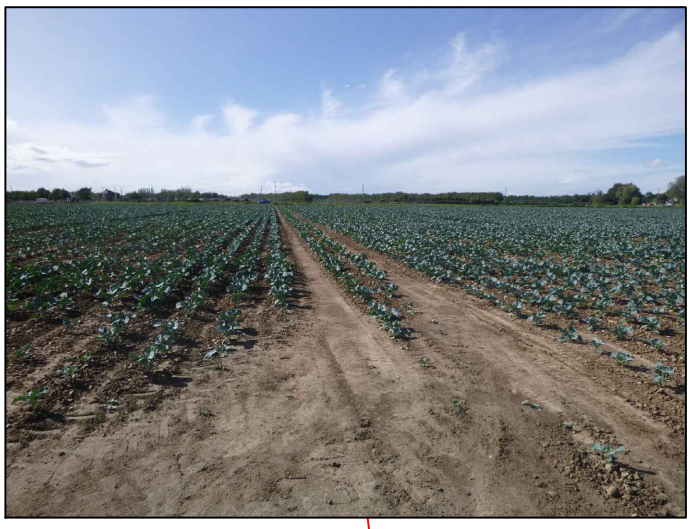
Project No.	D39032	Drawn By	GH
Client	Ashwood Homes	Checked By	PK
		Approved By	PK
Project	Yews Farm, Pinchbeck	Scale	NTS
		Date Drawn	05/01/2021
Title	Site Plan Showing General Site Views	Revision	
		Figure No.	D39032/03

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Project No.	D39032	Drawn By	GH
Client	Ashwood Homes	Checked By	PK
		Approved By	PK
Project	Yews Farm, Pinchbeck	Scale	NTS
		Date Drawn	05/01/2021
Title	Site Plan Showing General Site Views	Revision	
		Figure No.	D39032/03A

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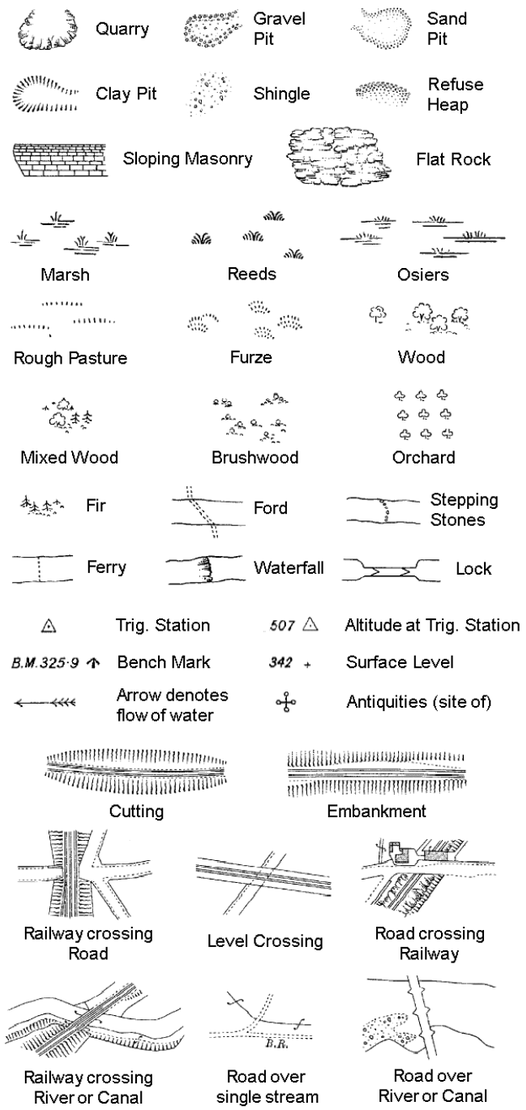
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APPENDIX V

Historical Plans

Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500



County Boundary (Geographical)

County & Civil Parish Boundary

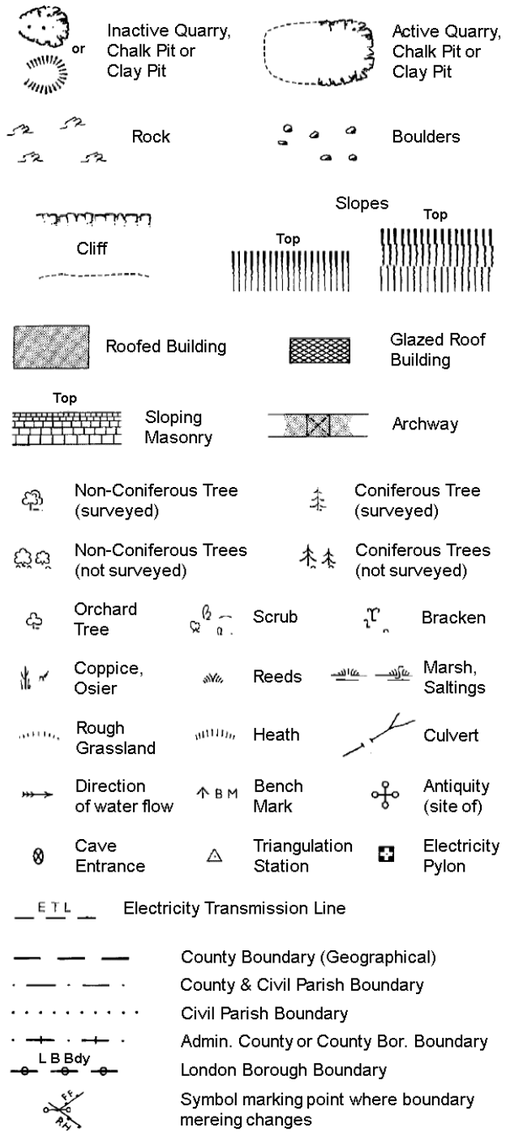
Administrative County & Civil Parish Boundary

Co. Boro. Bdy. County Borough Boundary (England)

Co. Burgh Bdy. County Burgh Boundary (Scotland)

B P B S	Boundary Post or Stone	P.C.B	Police Call Box
B.R.	Bridle Road	P	Pump
E.P	Electricity Pylon	S.P	Signal Post
F.B.	Foot Bridge	St.	Sluice
F.P.	Foot Path	Sp.	Spring
G.P	Guide Post or Board	T.C.B	Telephone Call Box
M.S	Mile Stone	Tr.	Trough
M.P M.R	Mooring Post or Ring	W	Well

Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



County Boundary (Geographical)

County & Civil Parish Boundary

Civil Parish Boundary

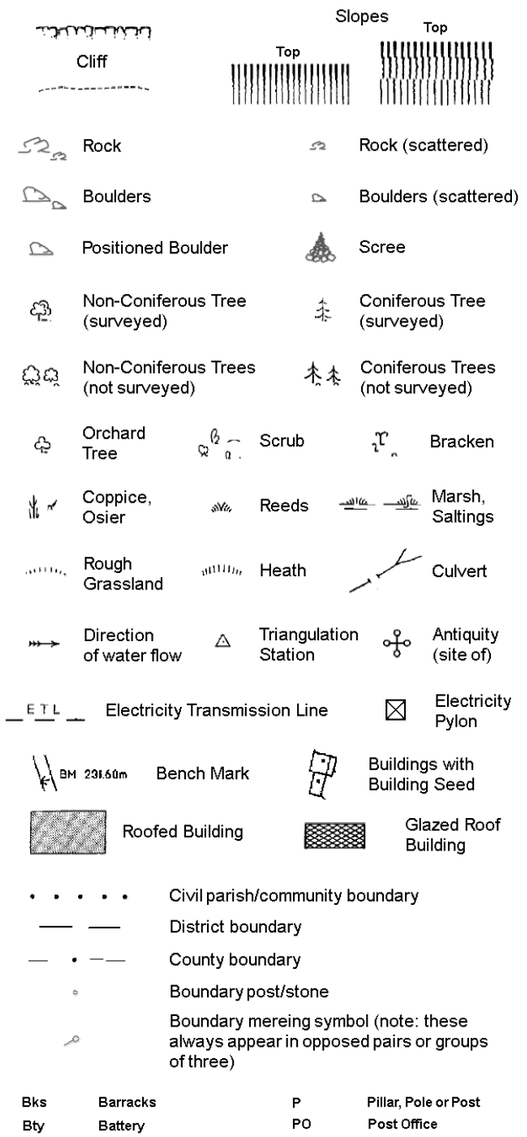
Admin. County or County Bor. Boundary

L B Bdy London Borough Boundary

Symbol marking point where boundary mereing changes

BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250



Civil parish/community boundary

District boundary

County boundary

Boundary post/stone

Boundary mereing symbol (note: these always appear in opposed pairs or groups of three)

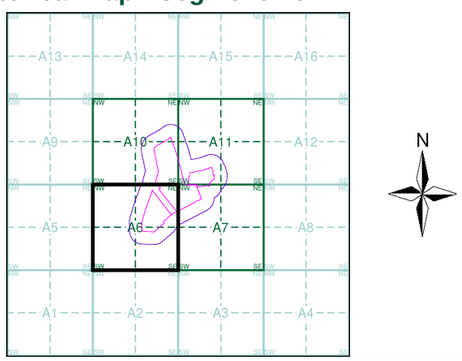
Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

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Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Lincolnshire	1:2,500	1888 - 1889	2
Lincolnshire	1:2,500	1904	3
Lincolnshire	1:2,500	1932	4
Ordnance Survey Plan	1:2,500	1968 - 1969	5
Additional SIMs	1:2,500	1969 - 1988	6
Ordnance Survey Plan	1:2,500	1980 - 1988	7
Additional SIMs	1:2,500	1982 - 1993	8
Additional SIMs	1:2,500	1986 - 1993	9
Additional SIMs	1:2,500	1990	10
Additional SIMs	1:2,500	1991	11
Additional SIMs	1:2,500	1992	12
Large-Scale National Grid Data	1:2,500	1995	13
Large-Scale National Grid Data	1:2,500	1996	14
Large-Scale National Grid Data	1:2,500	1996	15
Large-Scale National Grid Data	1:2,500	1996	16
Historical Aerial Photography	1:2,500	1999	17

Historical Map - Segment A6



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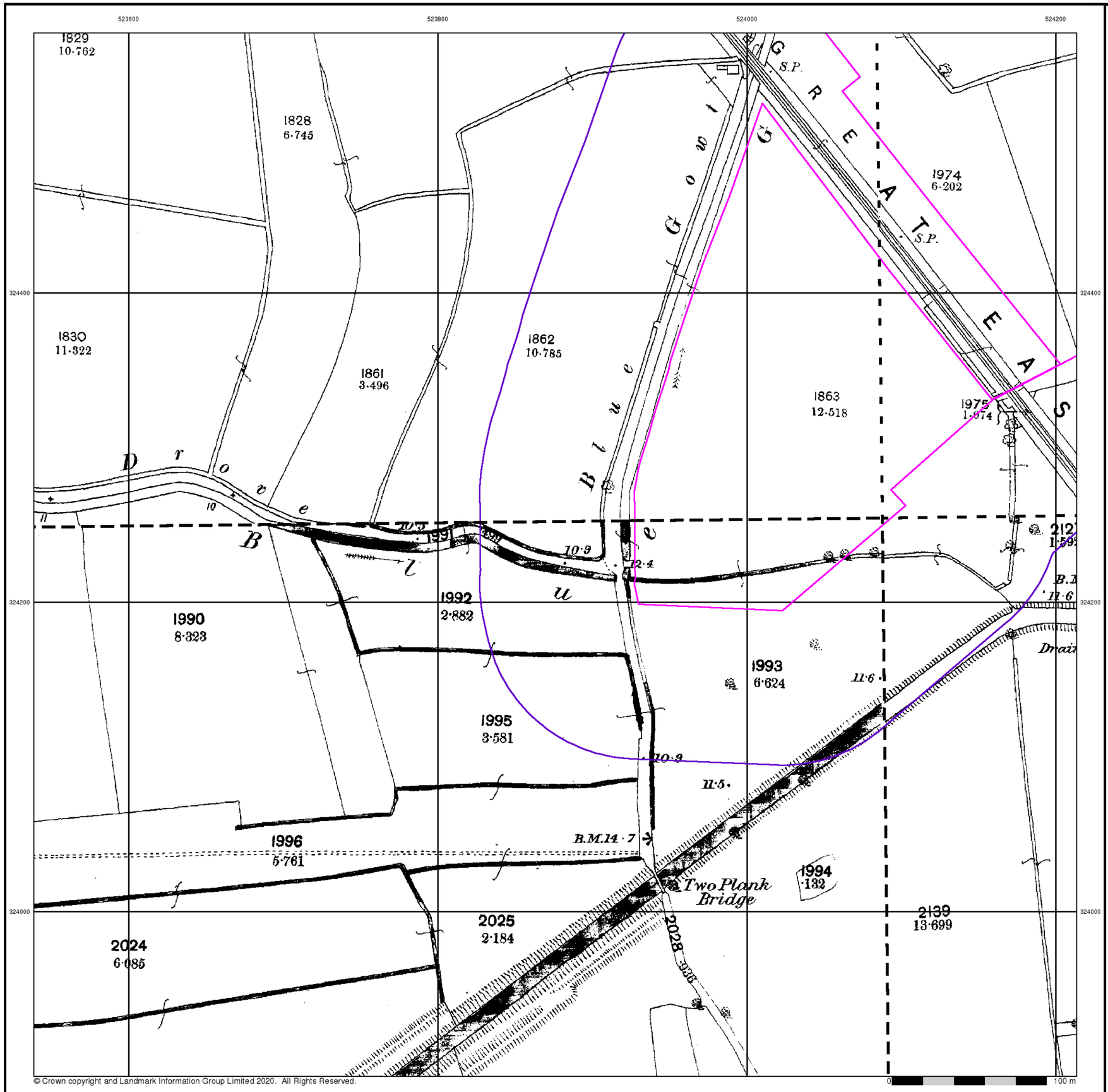
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National Grid Reference:	524170, 324560
Slice:	A
Site Area (Ha):	17.19
Search Buffer (m):	100

Site Details

Yews Farm, Pinchbeck, Spalding

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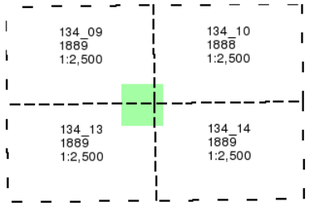
Lincolnshire

Published 1888 - 1889

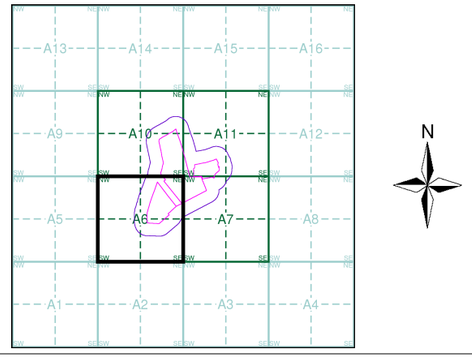
Source map scale - 1:2,500

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 and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below 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.

Map Name(s) and Date(s)



Historical Map - Segment A6



Order Details

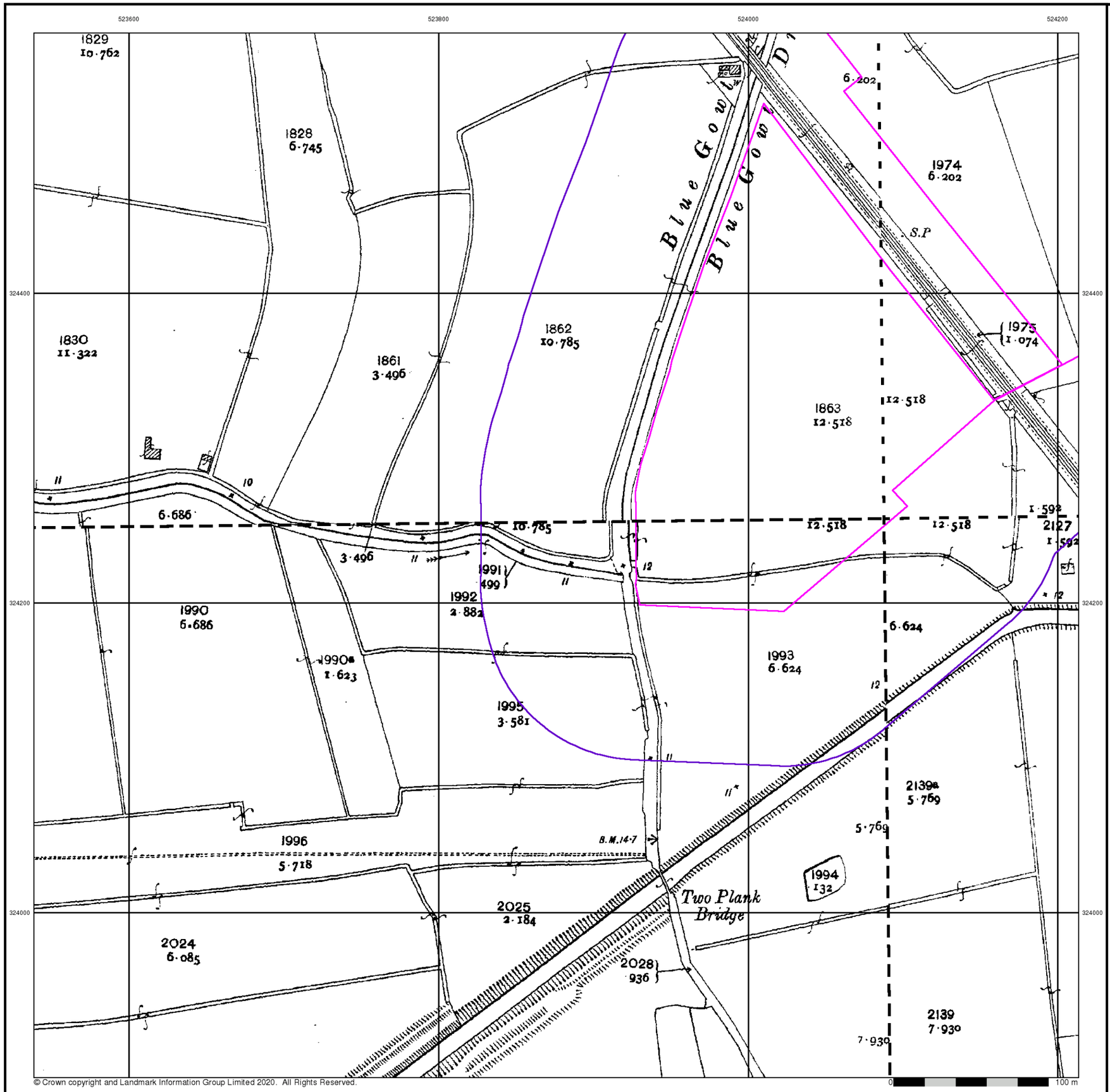
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Search Buffer (m):	100

Site Details

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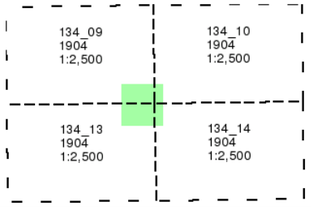
Lincolnshire

Published 1904

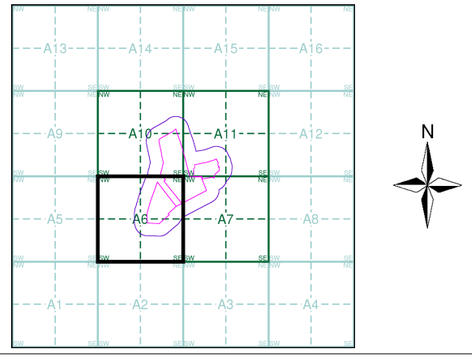
Source map scale - 1:2,500

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Map Name(s) and Date(s)



Historical Map - Segment A6



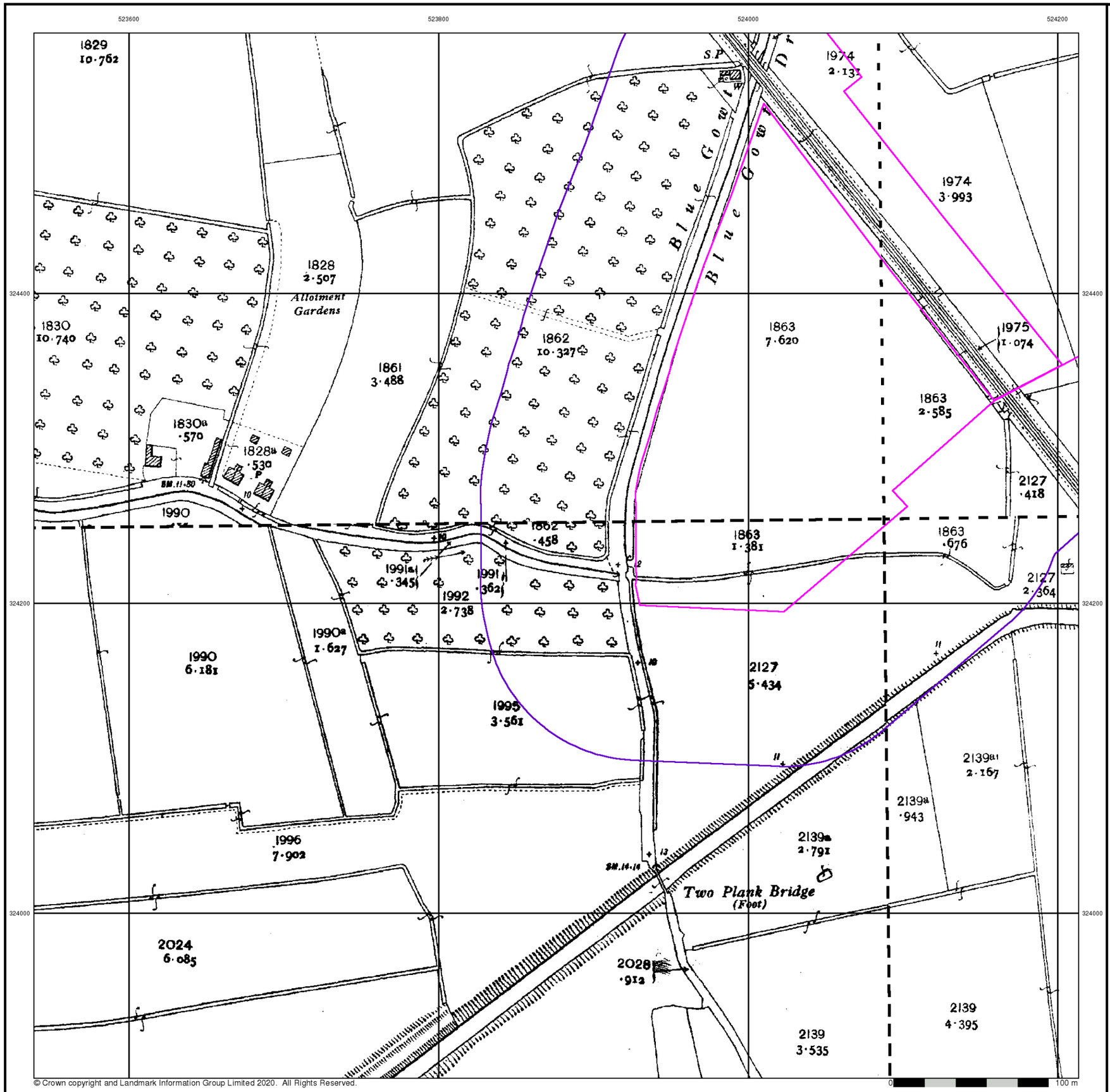
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Search Buffer (m):	100

Site Details

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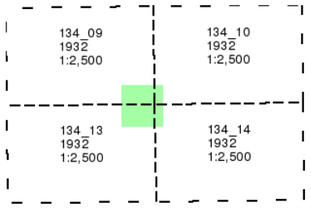
Lincolnshire

Published 1932

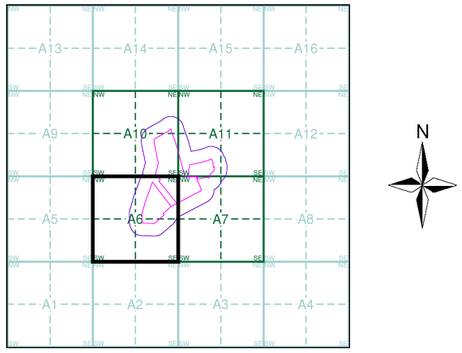
Source map scale - 1:2,500

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 and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below 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.

Map Name(s) and Date(s)



Historical Map - Segment A6



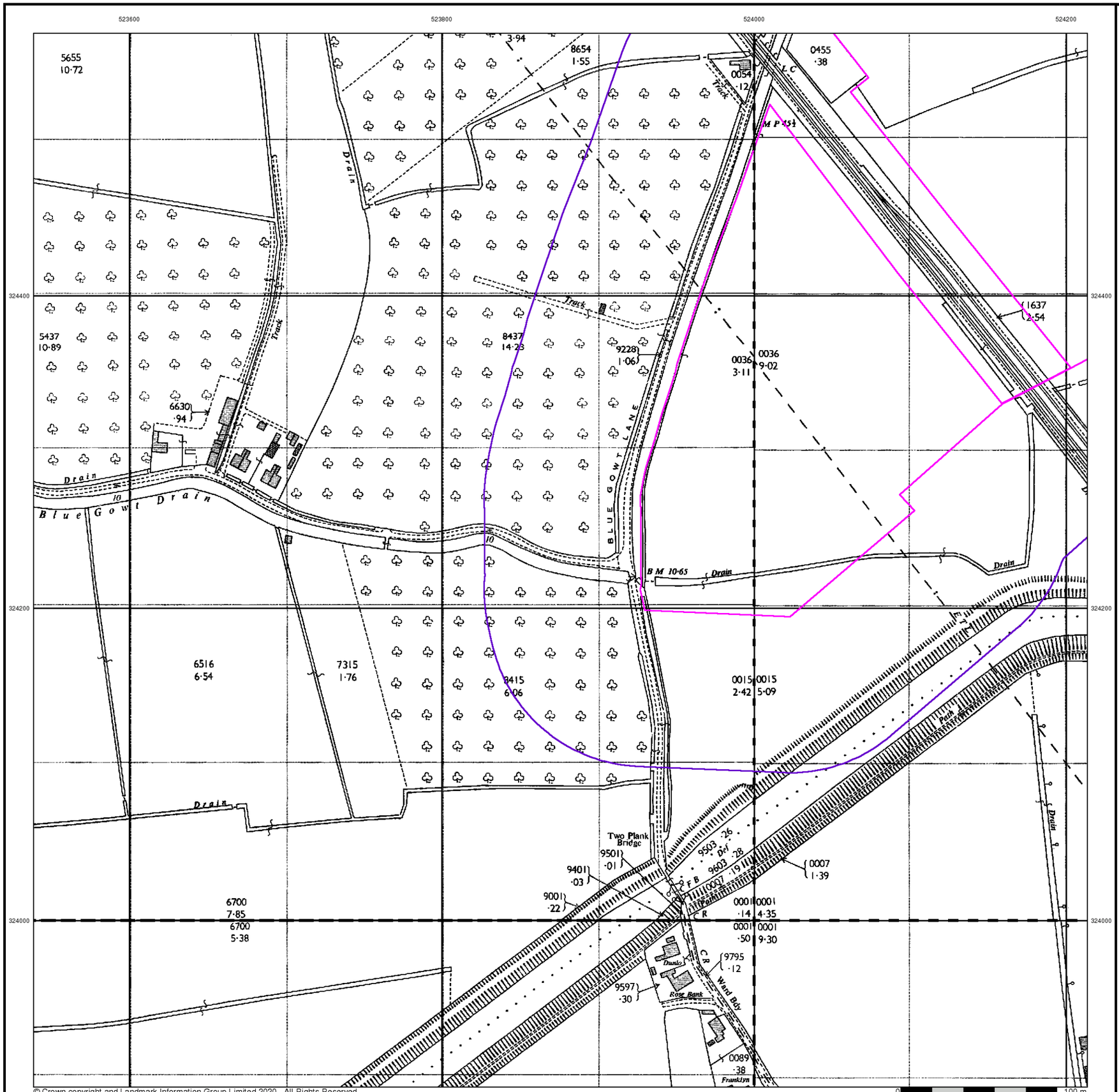
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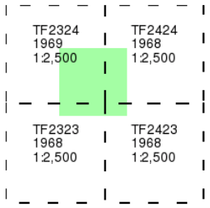
Ordnance Survey Plan

Published 1968 - 1969

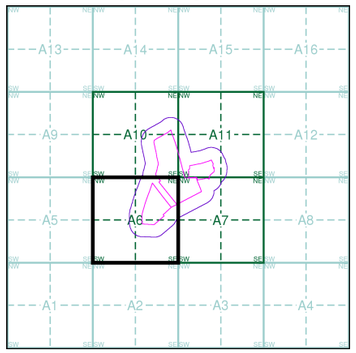
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Map Name(s) and Date(s)



Historical Map - Segment A6



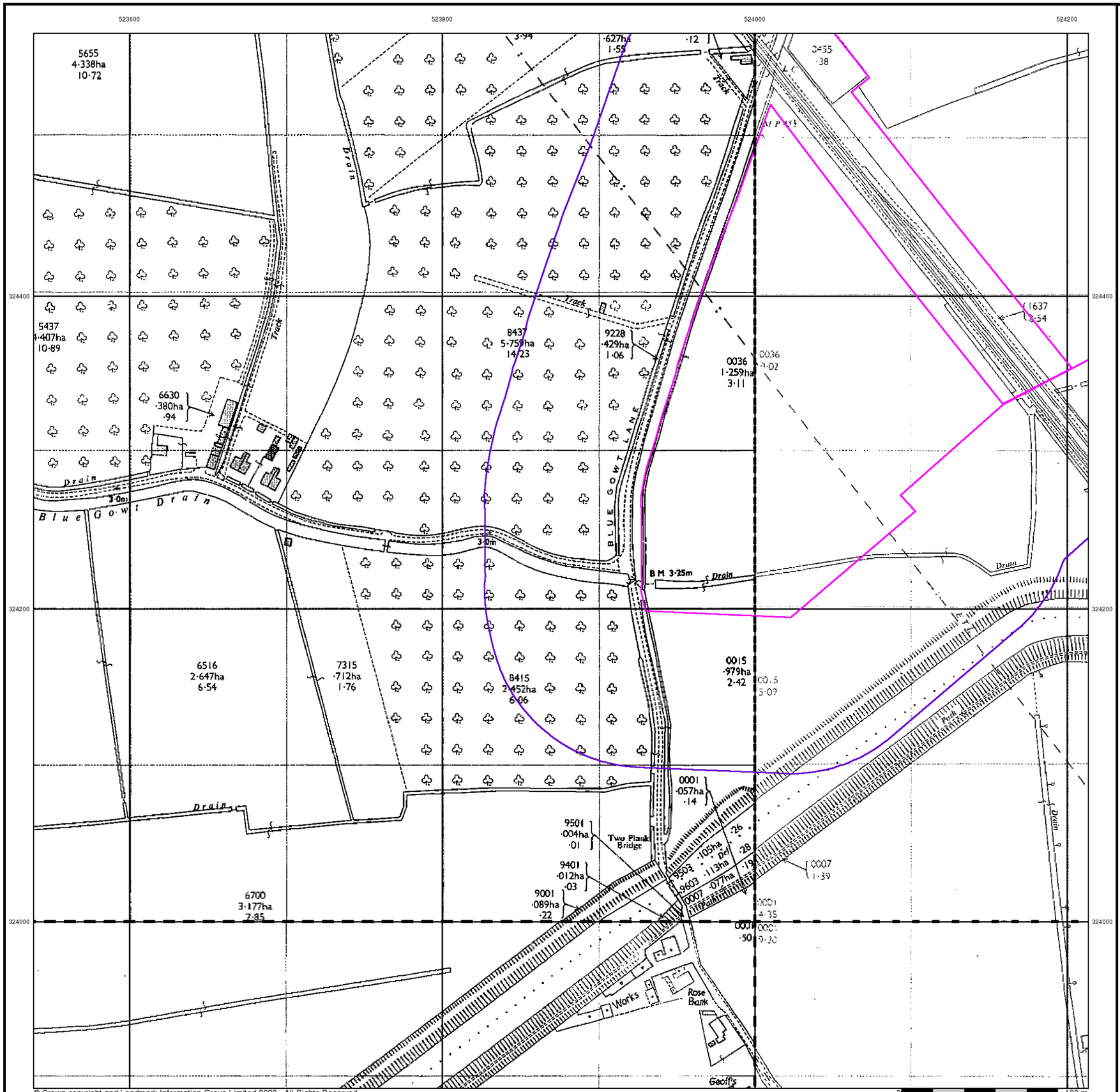
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Site Details

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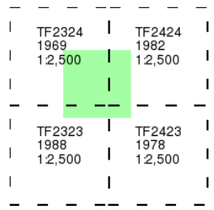
Additional SIMs

Published 1969 - 1988

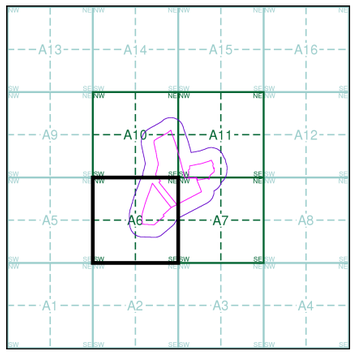
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A6



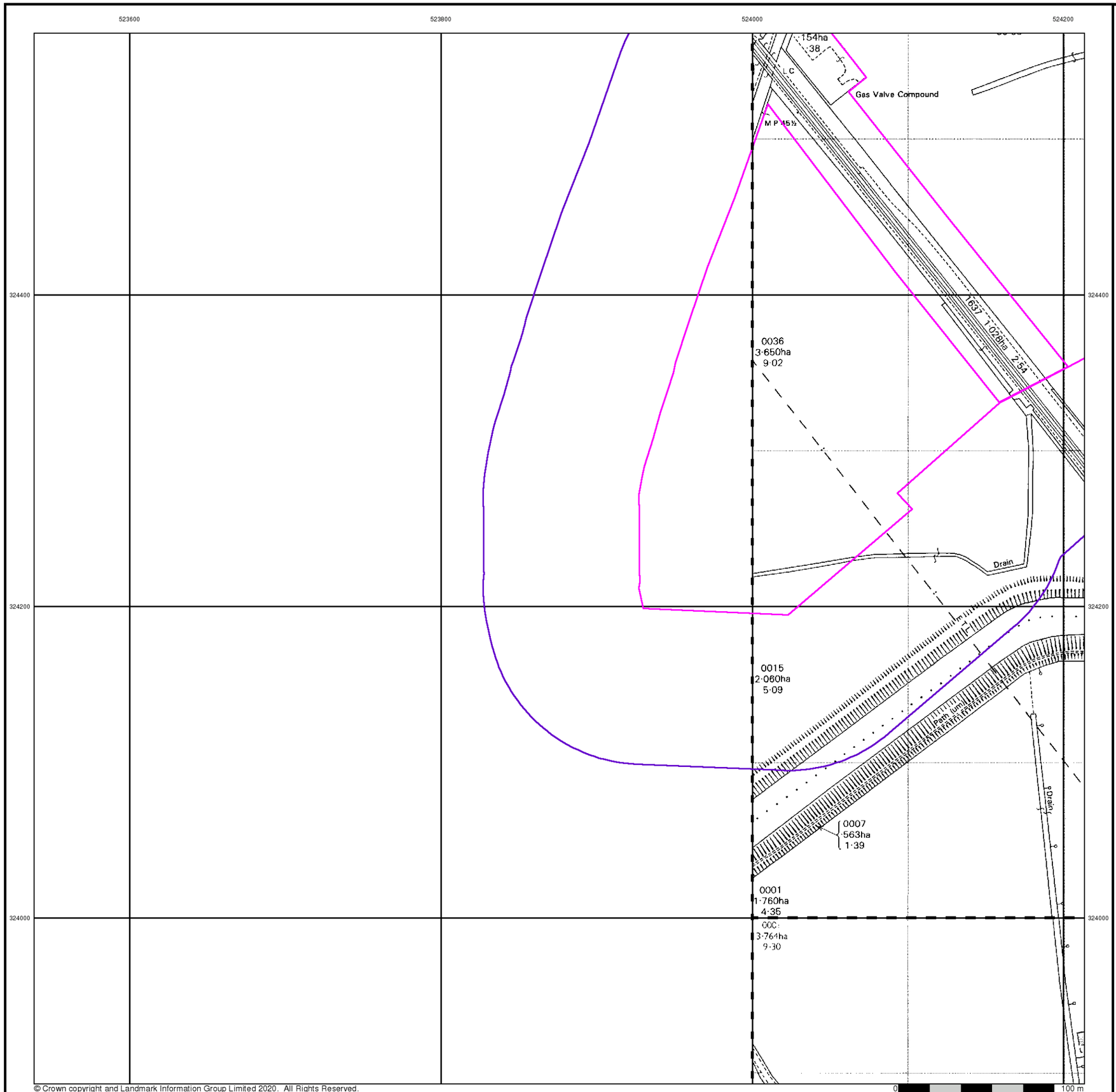
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Site Area (Ha):	17.19
Search Buffer (m):	100

Site Details

Yews Farm, Pinchbeck, Spalding

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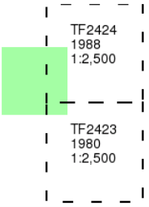
Ordnance Survey Plan

Published 1980 - 1988

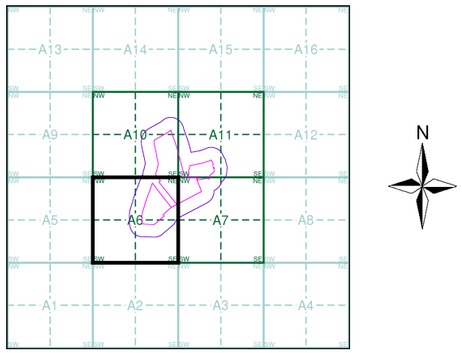
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Map Name(s) and Date(s)



Historical Map - Segment A6



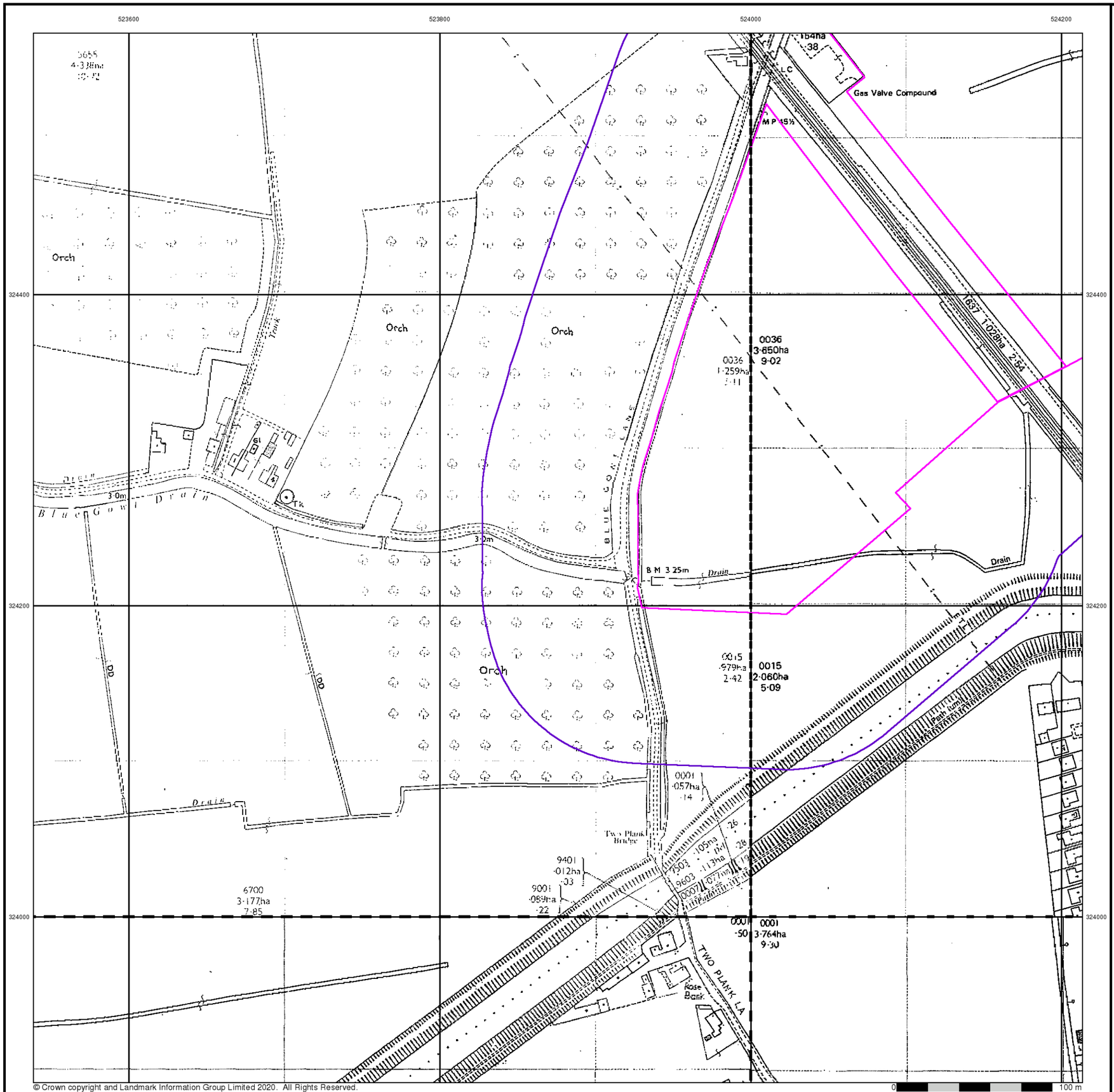
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National Grid Reference:	524170, 324560
Slice:	A
Site Area (Ha):	17.19
Search Buffer (m):	100

Site Details

Yews Farm, Pinchbeck, Spalding

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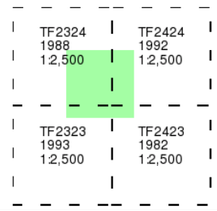
Additional SIMs

Published 1982 - 1993

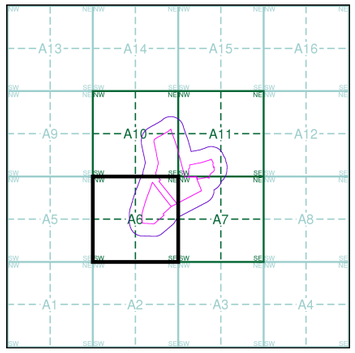
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A6



Order Details

Order Number:	261885339_1_1
Customer Ref:	D39032
National Grid Reference:	524170, 324560
Slice:	A
Site Area (Ha):	17.19
Search Buffer (m):	100

Site Details

Yews Farm, Pinchbeck, Spalding

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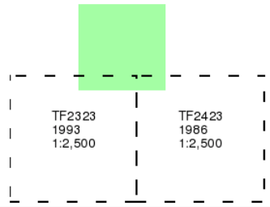
Additional SIMs

Published 1986 - 1993

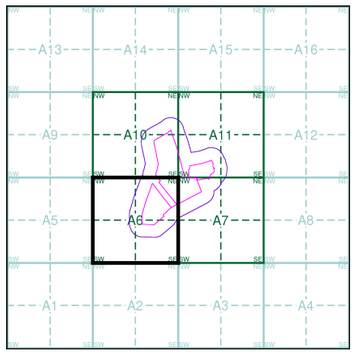
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A6



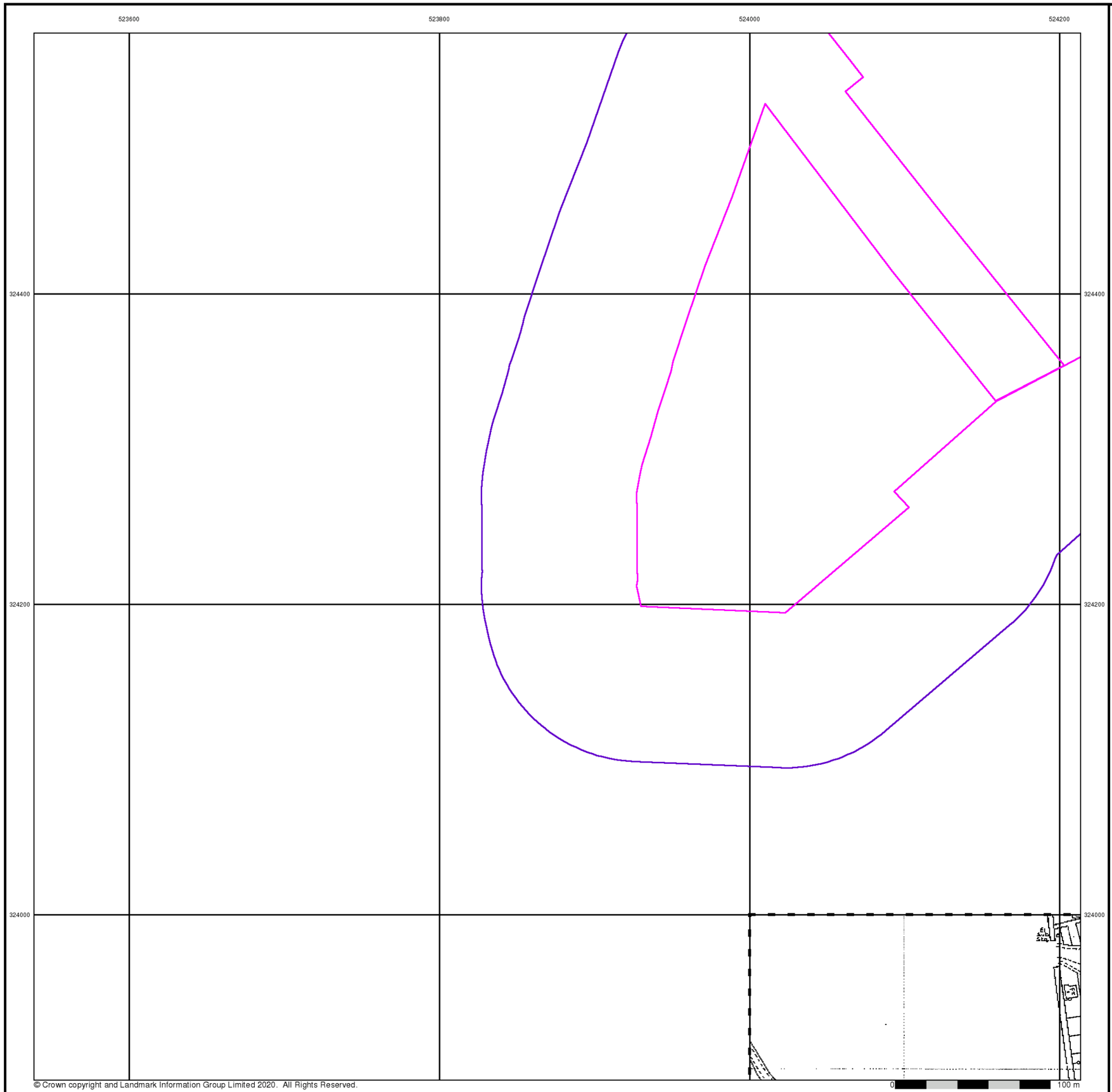
Order Details

Order Number:	261885339_1_1
Customer Ref:	D39032
National Grid Reference:	524170, 324560
Slice:	A
Site Area (Ha):	17.19
Search Buffer (m):	100

Site Details

Yews Farm, Pinchbeck, Spalding

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



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GeoDyne

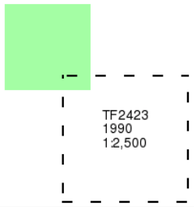
Additional SIMs

Published 1990

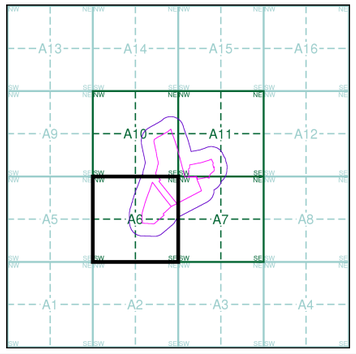
Source map scale - 1:2,500

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Map Name(s) and Date(s)



Historical Map - Segment A6



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