

Technical Note

Project:	Lower Hockenden Farm		
Subject:	Study Re: Changes in Landform and Potential Deposited Materials		
Author:	Dana Montgomery		
Date:	26/09/2022	Project No.:	5216374
Distribution:	London Borough of Bromley	Representing:	London Borough of Bromley

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
1.0	Draft for comment	DM	SM	JC	GM	14/09/22
2.0	Final	DM	SM	JC	GM	26/09/22

Client signoff

Client	London Borough of Bromley
Project	Lower Hockenden Farm
Project No.	5216374
Client signature / date	

Introduction

Lower Hockenden Farm (herein referred to as “the site”) is located west of Swanley in Bromley, England, adjacent to the A20 (closest postcode – BR8 7QW, approximate grid reference TQ 50106 68519); please refer to Drawing 1 in Appendix A for a site location plan.

During a previous site visit, representatives from Bromley Council indicated that materials may have been deposited at the surface of the site, leading to a change in the original ground levels.

Following from this visit, Bromley Council engaged Atkins Limited (Atkins) to undertake a desk-based study along with a site walkover to determine if it was likely that site levels have changed due to any recent deposits of materials.

Scope

In order to assessing the scale and nature of potentially deposited material, a site walkover was undertaken by Atkins on 25 July 2022 with a representative from Bromley Council.

Information such as site photographs, anecdotal information from Bromley Council, and the visual impressions of the site area have been collated along with data analysis using both LIDAR data and aerial imagery to ascertain changes in landform over time at the site. This includes the comparison of ground elevation profiles from Digital Surface Models (DSMs) over several years and calculations to provide indicative estimated volumes of materials that may have been deposited and removed from the site.

Publicly available LIDAR data from 2009, 2015, 2018 and 2020¹ and LIDAR data from 2022 obtained from the Environment Agency were used for the study, utilising open-source GIS software.

Background Information

The site is located within The Green Belt; to the north is Hockenden Lane and open land, to the west is Bourne Wood with public access along with agricultural land, and immediately to the south is Bournewood Sand and Gravel Limited – a currently operational sand and gravel quarry.

The site is currently owned by Killoughrey Properties Limited (Killoughrey). Killoughrey purchased the site in October 2016 and also owns the active quarry land situated to the south. Evidence on the London Borough of Bromley (Bromley Council) website indicates the site is under license to Bournewood Sand and Gravel Limited. Bourne Wood, to the west of the site, is owned by Bromley Council.

Bromley Council provided Atkins with a hand-drawn sketch from the site visit and the areas of potential material placement are shown in Figure-1 below:

¹ DEFRA (2019), Defra Survey Data Download, <https://environment.data.gov.uk/DefraDataDownload/?Mode=survey>



Figure-1 - Areas of Potential Material Placement (Source: Bromley Council)

An enforcement notice was previously issued to Killoughrey in September 2021 (Ref: 21/00270/CHANGE) regarding both the storage of metal containers and other equipment in the centre of the site as well as the formation of earth bunds around parts of the site perimeter. The storage of equipment was issued as a material change of use to land designated in Bromley Council's Local Plan as part of The Green Belt (Policy 49), and the formation of earth bunds was issued as an operational development – the enforcement notice regarding the equipment storage is currently under appeal, and the equipment remains situated on the site. According to anecdotal evidence from Bromley Council personnel, the second enforcement notice was withdrawn by the Council pending further site investigation.

For the purposes of discussion within this technical report, the site has been divided into seven Zones and given reference names as shown on Drawing 2 in Appendix A:

- West Bunds
- West Field
- Central Ditch
- Central Field
- South Bunds
- East Field
- East Bunds

Site Walkover

The site walkover was undertaken on 25 July 2022 by an Atkins employee and Bromley Council personnel - a copy of the site diary including photographs is provided in Appendix B.

A summary of the findings of the site walkover are as follows:

Access:

- Access to the site was via a farm access road created parallel to the public footpath.
- The farm access road was formed of woodchip material with various anthropogenic inclusions including but not limited to:
 - Insulation materials;
 - Frequent hard and soft plastics of various sizes;
 - Occasional fragments of metal of various sizes such as a metal spring (~10 cm), nails (~1-3 cm); and
 - Occasional pieces of cables.

East Bunds:

- The bunds/mounds situated along the A20 ('East Bunds') were ~1.5 to 2.0 m in height and comprised branches and wood fragments, concrete boulders, soft plastics, and plasterboard along with further woodchip material in a general sandy gravel matrix.
- Some areas of the East Bunds were found to include weathered Chalk and flint gravels and Chalk boulders.
- The East Bunds were also observed to include further anthropogenic materials such as hard plastics (~3 to 10 cm in diameter), occasional metal fragments, wiring, glass, broken ceramics, brick fragments and insulation materials.

East Field:

- A burning pit located near the tunnel under the A20 in the south-east corner of the site (East Field) was noted to be smoking at the time of the site walkover, indicating recent burning of unknown materials.

Central Field:

- Earth mounds situated within Central Field were ~1.0 to 1.3 m in height comprising Made Ground of light grey gravelly silty sand. The gravels were fine to coarse granite ballast with some cobbles of brick and concrete with occasional ceramic fragments.
- Anecdotal information from Council personnel suggests this field may be used as an unlicensed recreational go-cart field.
- Some discarded litter including metal cans and evidence of burning waste within the Central Field may be related to trespassers.
- The equipment and container storage remains in situ.

West Field/West Bunds:

- Within the West Field/West Bunds, there were further mounds of Made Ground ~1.5 to 2.0 m high consisting of sandy gravelly materials. These gravels were fine to coarse siliceous and calcareous ballast along with frequent brick and concrete. Occasional ceramic and clay pipe fragments, metals, bricks, and wood chipping.
- In addition there were mounds of weathered Chalk gravels and boulders, angular cobbles of black tarmac with some minor clinker noted.

Central Ditch:

- The stream within the Central Ditch was dry at the time of the site walkover.
- The ditch contains numerous trees and other vegetation.

Bourne Wood (Off-Site):

- The natural topsoil within Bourne Wood, to the west of the site, is light brown slightly gravelly silty fine to medium sandy topsoil.
- There is a noted difference in ground level between the site and Bourne Wood, with the site appearing to be ~1.5-2.0 m higher in elevation than the adjacent woodland.

Aerial Imagery

Both publicly available and licensed aerial imagery was inspected to gain information about potential changes in landform at the site over recent years.

Aerial imagery downloaded from the DEFRA Data Services Platform from 2011 shows the site comprising open land with some evidence of tracks and surface disturbance as shown in Figure-2:



Figure-2 - 2011 Aerial Imagery (DEFRA)

Hard-copy aerial imagery provided by Bromley Council taken largely of the adjacent sand and gravel pit also includes some visibility of the site.

Some of the photographs indicate the establishment of bunds and surface disturbance on the site as seen in the figures below:



Figure-3 - Aerial Imagery (2012) Showing East Bunds (Bromley Council)



Figure-4 - Aerial Imagery (2010) Showing Surface Disturbance and Potential Access to West Field (Bromley Council)

Recent satellite imagery from ESRI (2022) shows the probable bunds in the West Field along with the container and equipment storage in the Central Field and surface disturbance across both the West and Central Fields:



Figure-5 – ESRI Satellite Imagery (2022) Showing Equipment Storage and West Bunds (Esri, Intermap, NASA, NGA, USGS | Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS | Maxar, Microsoft)

Publicly available Google Satellite imagery² indicates further detail with regards to the West and East Bunds, as it appears that individual loads of deposited material are visible along the length of the two bunded areas, and the loads appear to be of varying materials in both texture and colour.

In addition to the bunded areas, there is varying vegetation growth apparent mainly within the Central Ditch and the East Field, along with what seems to be lower lying grasses in the northern section of the Central Field. The southern portion of the Central Field appears to have had the vegetation cleared in Figure-5 above, or it has potentially been disturbed through vehicle movements.

LIDAR Data Analysis

The following LIDAR datasets were utilised within this assessment:

- 2009, 2015, 2018, and 2020 DSM (DEFRA); and
- 2022 DSM (Bromley Council)

Available Digital Terrain Models (DTMs) were also consulted; DTMs generally indicate bare-earth elevations while DSMs provide ground elevation including features such as trees, buildings, etc. The 2022 data provided by Bromley Council was as a DSM format and as such it was decided that DSM data would be used for consistency in the assessment. In addition, some elevated features – such as the bunds situated on the site – were less apparent within the DTMs due to the way the data is collected in line with its purpose as a bare-earth elevation model, and the bunds are additive features situated above the bare-earth. As an example, the elevation of one point from the DTM (bare-earth) in 2020 was 74.24 m, whereas the same point in the DSM (ground plus other features) from the same year was 76.88 m.

Drawing 3 in Appendix A provides a side-by-side comparison of the DSMs from 2009-2020 and Drawing 4 provides a closer view of the DSM from 2022 as provided by Bromley Council; brown indicates a higher elevation than green.

While the 2009 data is only partially available due to gaps in the original collection of the LIDAR data, the South and East Bunds are visible as elevated features in all DSMs from 2009-2020; the landform of the south-east area of the site from before 2015 is unable to be determined

In addition, in the 2018 DSM shows further elevated features/potential mounds in the southern part of the Central Field – these are then shown as removed (i.e. a decrease in elevation) in the 2020 DSM.

In Drawing 4 the West Bunds are now also visible, and the South and East Bunds appear to have potentially been augmented with further deposited material inside the original bund features. The area of equipment and container storage is also now visible in the Central Field.

The DSMs – as a collection of individual data points containing the elevation in metres of that specific point – are able to be subtracted from one another to gain insight into the relative increase and/or decrease of ground levels over time:

$$Elevation\ Change = Cell\ (Year\ 2) - Cell\ (Year\ 1)$$

As can be seen in Drawing 5 in Appendix A, where red indicates an increase in elevation and grey indicates an elevation decrease, there have been demonstrated changes in the landform over time since 2009.

Key changes include but are not limited to:

Table-1 - Summary of Differences in Landform Between Years Based on DSMs

Years	Noted Changes
2009 to 2015	<ul style="list-style-type: none"> • South Bunds potentially visible as red lines across the south of the site area • Wider minor increases in elevation in both West and Central Fields could potentially be due to vegetation growth

² Google Maps (2022), Available: <https://www.google.com/maps/@51.3965614,0.1568127,747m/data=!3m1!1e3>

Years	Noted Changes
2015 to 2018	<ul style="list-style-type: none"> • A number of mounds of potential stored material are visible in the southern portion of the Central Field – four larger mounds with an elevation increase of > 6 m as well as a collection of smaller mounds/increases in elevation • It appears that there may have potentially been some excavations within the same area as there is a decrease in ground level of ~3 m in the south portion of the Central Field • The landform generally seems to rise from west to east across the Central and West Fields towards the A20 • The East Bunds are visible along the A20
2018 to 2020	<ul style="list-style-type: none"> • The potential mounds of stored material and excavation area noted above appear to have been both removed and infilled, respectively • Further small piles of potential material appear to have been placed in the northern section of the East Field
2020 to 2022	<ul style="list-style-type: none"> • The small piles of potential material in the northern section of the East Field have been removed • A further mound of potential material is visible in the eastern section of the West Field, with an increase in elevation of ~2 to 3 m between 2020 and 2022 • Potential smoothing of the landform is visible in the southern area of the Central Field, as there are alternating increases and decreases of elevation across the area • The West Bunds are now visible with a height increase up to ~2.8 m in places • The South and East Bunds appear to have been further augmented with more material, in some areas showing an ~2-3 m increase in elevation • The area of equipment and container storage in the Central Field is visible • Some minor potential materials have been placed in the north-east corner of the West Field along the Central Ditch • A potential area of excavation is visible at the southern boundary of the site near the entrance to the adjacent sand and gravel quarry

Within the central part of the South Bunds in 2009-2015, there was some evidence of materials movements on both sides of one of the tracks indicating that the landform in this area may have been flattened (red is an increase in elevation and grey is a decrease):

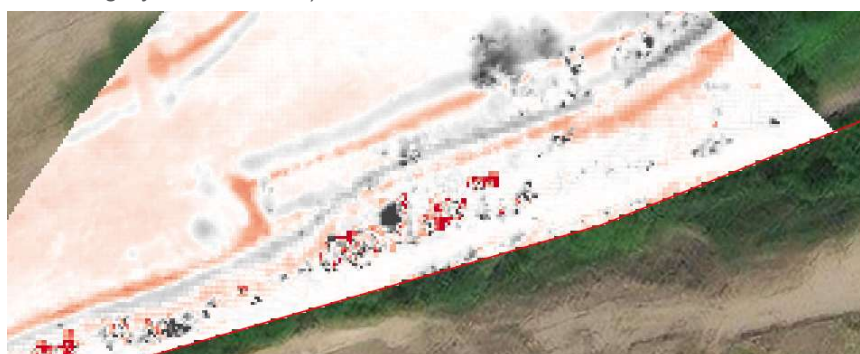


Figure-6 – 2009-2015 DSM Difference in Central Area of South Bunds

The main difference to the South Bunds able to be ascertained from the available data was that in 2020-2022, a feature is visible which appears to be a mound of material formed to the north of a track:

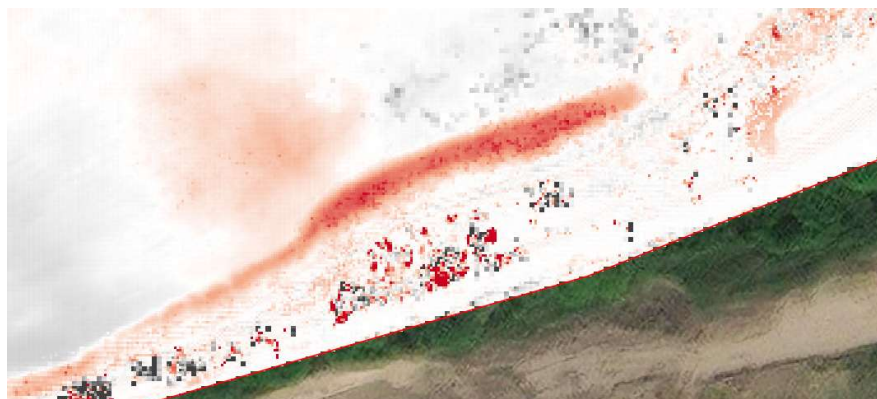


Figure-7 – 2020-2022 DSM Difference Showing Elevated Feature in South Bunds

This also appears to be visible in aerial imagery:



Figure-8 - Aerial Imagery Showing Elevated Feature in South Bunds (Esri, Intermap, NASA, NGA, USGS | Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS | Maxar, Microsoft)

Using the data from the DSMs within this area, one point is at an elevation of 70.7 m in 2020, whereas the same point in 2022 shows an elevation of 72.7 m.

Potential Indicative Volumes

By utilising the DSM difference calculations above, approximate volume balances can be calculated between the DSMs for specific years. It was necessary to use DSM models and not DTMs in order to capture the recent changes in landform at the site and align with the 2022 data. As such, rather than perform these calculations on the entire site which would include wider changes in tree height, vegetation growth, etc., it was undertaken on specific zones to give indicative volume balances for these zones.

As the most significant differences were noted between the DSMs from 2020 and 2022, these were the datasets utilised for the indicative volume calculations as such:

$$Total\ Volume = \sum Cell - Cell' * x.resolution * y.resolution$$

Where the x. and y. resolutions are both 0.5 m as the existing resolution of these two raster DSMs.

These calculations were performed for: West Bunds, West Field, South Bunds, and East Bunds as the zones showing the most significant elevation changes.

It should be noted that these are **indicative volume balances only** due to the inherent limitations of performing these calculations on the available LIDAR data – these calculations include all changes in elevation regardless of the cause; changes in vegetation height (both growth and removal), anomalous data points within the LIDAR data itself, the introduction or removal of man-made features/equipment, etc. However, it will provide a high-level indication of the changes in the volumes of the landform at the site between 2020 and 2022.

Table-2 - Indicative Changes in Landform Volume by Zone (2020-2022)

Area Reference	Area of Zone (m ²)	Indicative Volume Balance (m ³)
West Bunds	9,950	+12,690
West Field	31,240	+11,270
South Bunds	4,260	+3,550
East Bunds	6,100	+13,640

The South Bunds have been subject to changes in vegetation presence and the existence of tracks within this area, which both would have an impact on the above volume calculations. When a smaller area of the wider South Bunds is assessed – focussing on the linear elevated feature visible in Figure-7 and Figure-8 – the indicative volume change of this feature only is +1,910 m³.

As a form of quality control, volume changes for areas of the site where no significant elevation changes are visible were also calculated for comparison.

The locations of the check areas are shown in yellow in Figure-9.



Figure-9 - West Field Check and Central Field Check Locations

The two areas within the northern sections of the West Field and Central Field were extracted in the same way and indicative volume changes were calculated and provided in Table-3.

Table-3 – Control Area Volume Calculations (2020-2022)

Area Reference	Area of Control Area (m ²)	Indicative Volume Balance (m ³)
West Field Check	2,540	-410
Central Field Check	2,300	-650

The volume balances shown in Table 3 for the control areas are less than 5% overall of those in Table-2 and indicate a lower change in volume.

Elevation Profiles

Profile cross-sections across the site, using elevation data from LIDAR DSM data compiled across the available years to identify trends in the elevation profiles, are shown on Drawing 6 in Appendix A.

Drawing 7 (Sheets 1 of 2 and 2 of 2) provided in Appendix A show the six elevation profiles and a summary of the findings are provided in Table-4 below. When mentioned, the year text is in the same colour as the elevation profile on Drawing 7:

Table-4 - Summary of Elevation Profiles (2009 - 2022)

Cross-Section Reference	Comments
A	<ul style="list-style-type: none"> The West Bunds are visible in 2022 closest to A The mound identified near the centre of the West Field is also visible in 2022 Tree presence/growth may be the cause of the changes in elevation across all years close to A'
B	<ul style="list-style-type: none"> Tree presence/growth may be the cause of the changes in the 2020 and 2018 lines The East Bunds are visible from 2015 onwards as two mounds towards B', with further changes in elevation in subsequent years The extension of the East Bunds is visible in 2022 towards B'
C	<ul style="list-style-type: none"> The temporary mound of material in the Central Field discussed in Table-1 above is visible in 2018, and is no longer present in 2020 The excavations undertaken in 2018 are also visible towards C'
D	<ul style="list-style-type: none"> The East Bunds (in the south-east corner of the site) are visible from 2015 onwards, with further material evident through an increase in elevation in 2022 Tree/vegetation presence/growth may be the cause of the changes in the 2020 and 2018 lines, though these are not present in 2022 and this is unable to be confirmed
E	<ul style="list-style-type: none"> Provides an overall profile of the entire site from west to east The West Bunds are visible in 2022 The temporary mound in 2018 is visible to the east of the Central Ditch The East Bunds are visible towards E' from 2015 onwards with assumed vegetation growth to the west of this
F	<ul style="list-style-type: none"> The elevated mound of potential materials in the eastern central portion of the West Field are visible in 2022 A slow increase in elevation across the southern portion of the West Field is noted from 2009 through to 2022 The West Bunds are visible towards F' in 2022

Conclusions

Lines of evidence including the site walkover, aerial imagery, LIDAR DSM data from 2009 to 2022, indicative volume calculations from various zones across the site, and elevation profiles compared year to year were used to evaluate if there has been material deposited or excavated on the site since 2009.

The formation of bunds in the west, south, and east areas of the site as well as an overall increase in the elevation of the West Field are apparent from the data. Some temporal elevation changes were identified in the southern portion of the Central Field, with potential mounds of material being established (according to the data ~6 m in height) and then removed. Reduction in elevation of up to ~4 m is also seen at areas of probable excavation and infilling, and in other areas around the wider site.

The volume balance calculations indicate that there has been an overall increase in the deposition of materials from numerous areas across the site.

From the evidence gathered during the site walkover, at least a proportion of the recently deposited materials are likely to be Made Ground of varying composition including sandy gravels with anthropogenic materials such as woodchip, plastics, metals, concrete, bricks, ceramics, etc. The material is of unknown quality in terms of chemical components and the source(s) of the material is not known.

Appendices

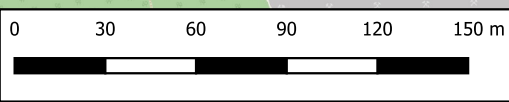


Appendix A. Figures

Figure 1	Site Location Plan
Figure 2	Reference Zones
Figure 3	LIDAR DSM Data (2009, 2015, 2018, 2020)
Figure 4	LIDAR DSM Data (2022)
Figure 5	Difference Between DSMs (2009 to 2015, 2015 to 2018, 2018 to 2020, 2020 to 2022)
Figure 6	Elevation Profile Cross-Sections
Figure 7	Elevation Profile Cross-Sections (Detail A - C) (Sheet 1 of 2)
Figure 7	Elevation Profile Cross-Sections (Detail D - F) (Sheet 2 of 2)



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LEGEND

- Site Boundary
- Zones**
- Central Ditch
- Bunds
- Central Field
- East Field
- West Field

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Site Area References						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Draft	01	DM	SM			09/22

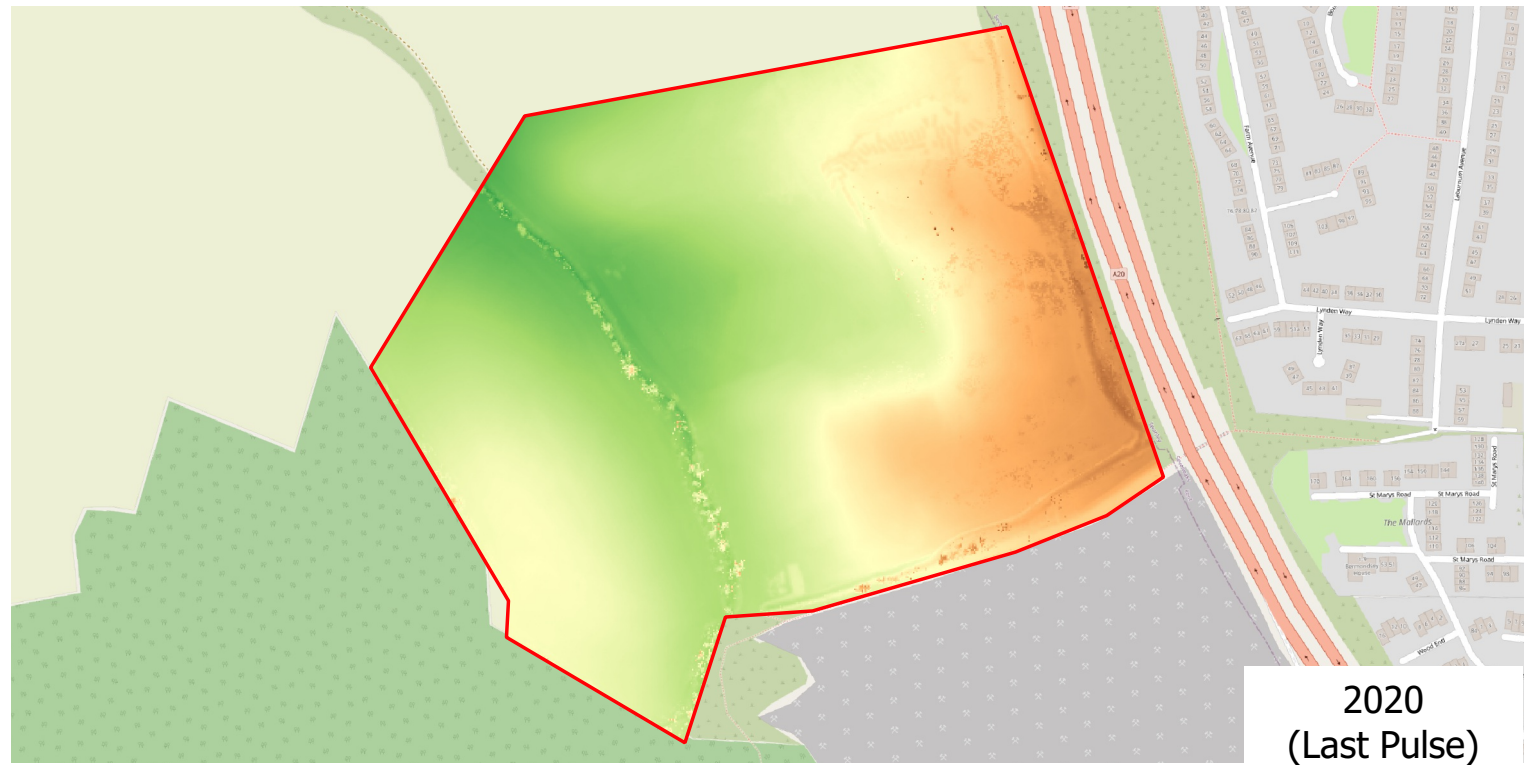
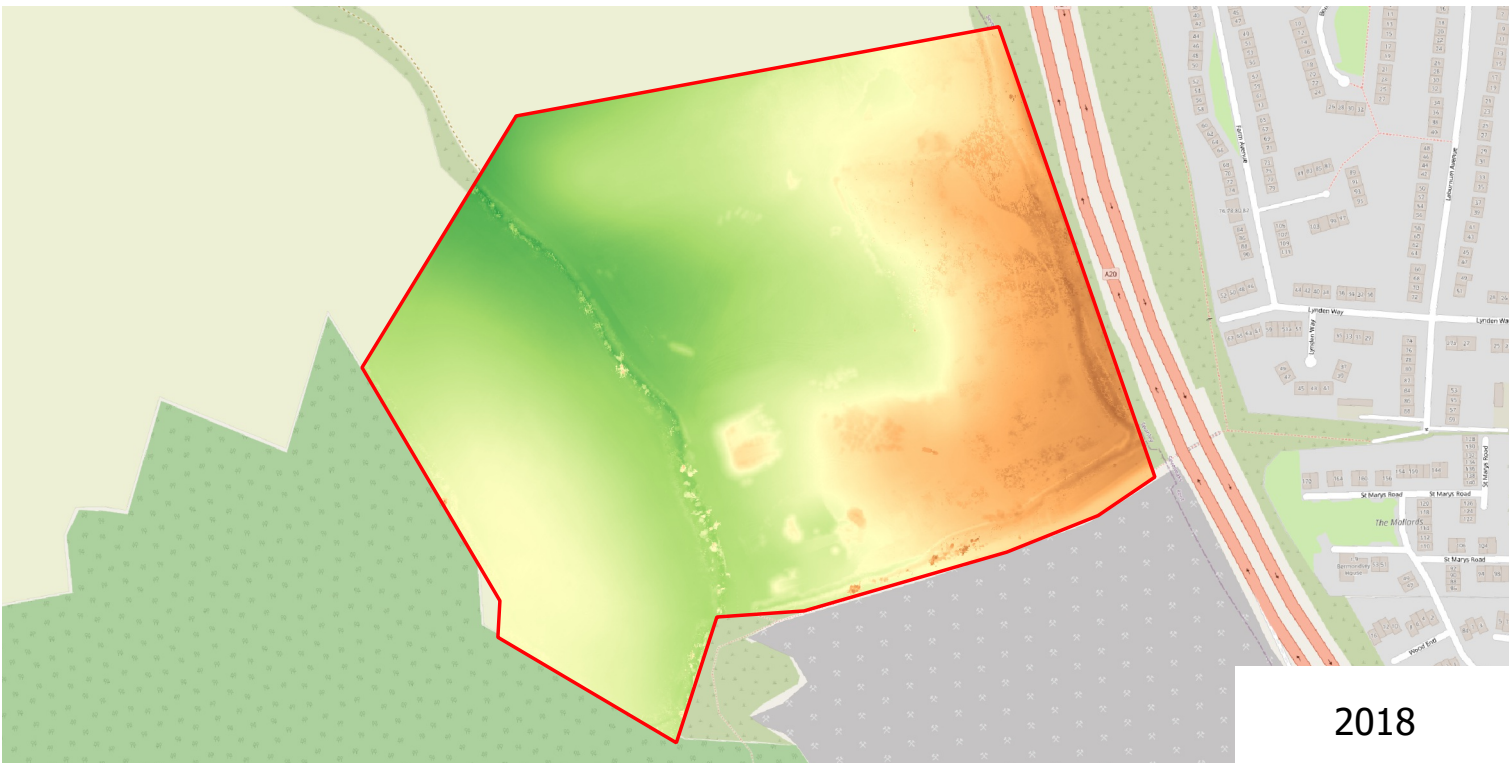
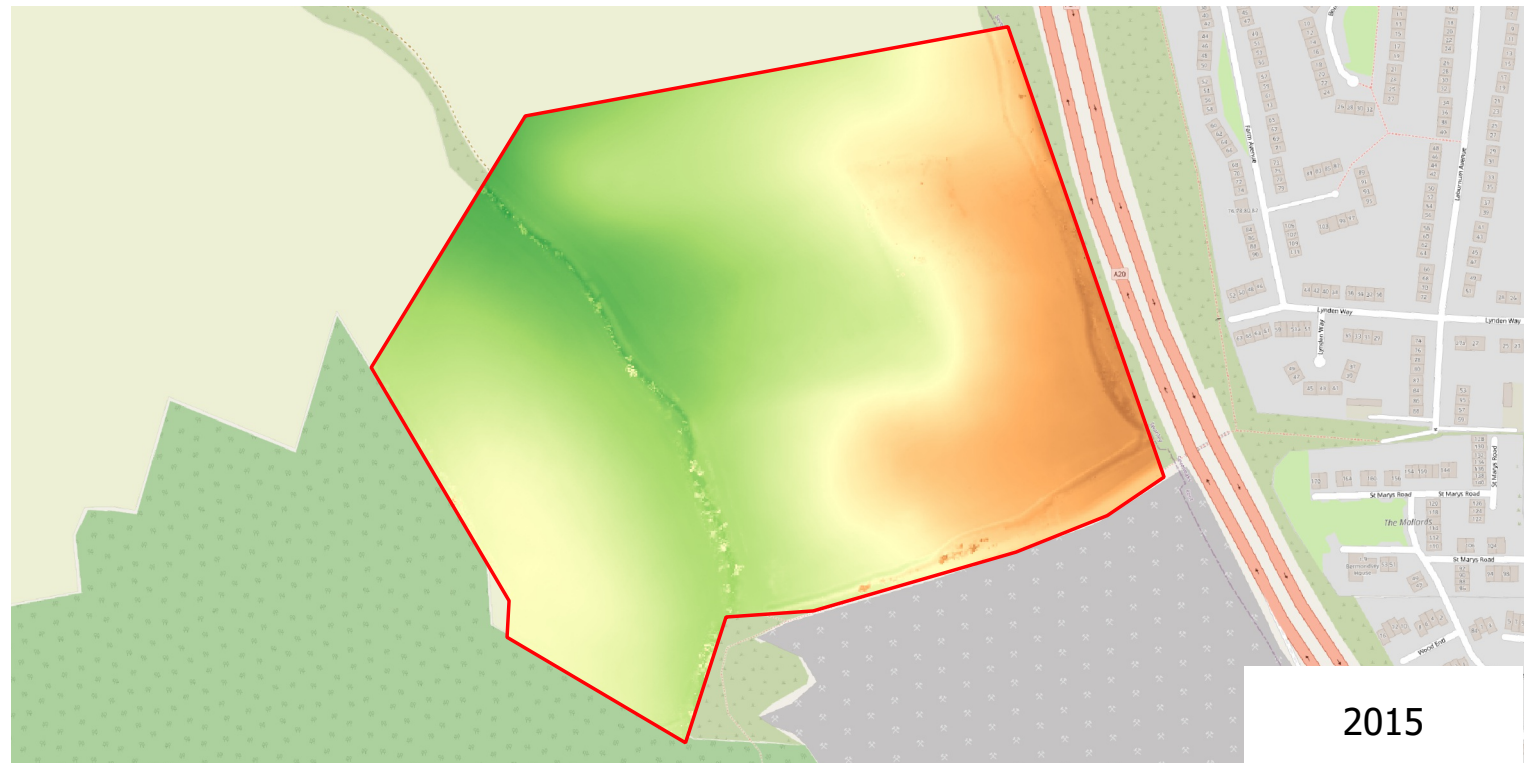
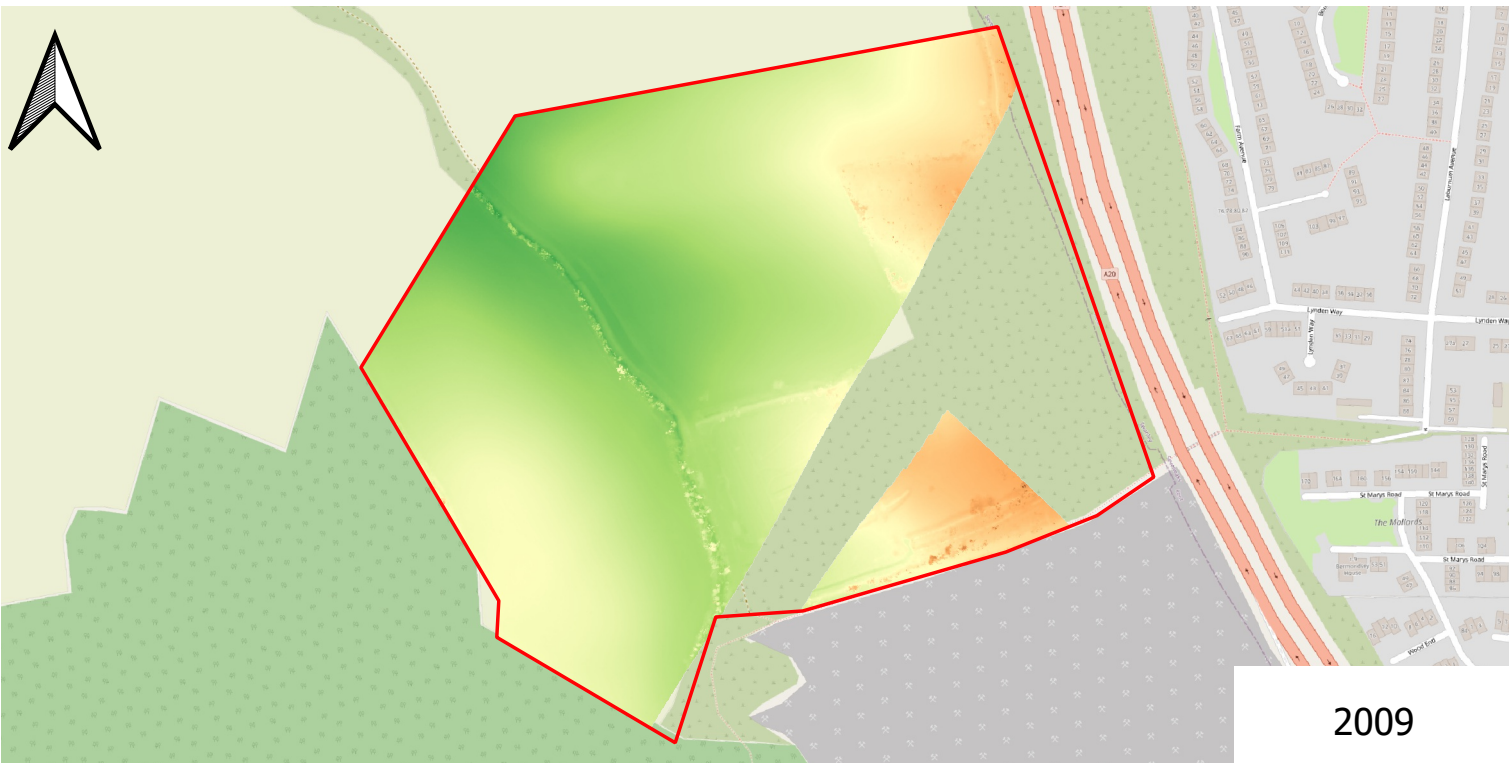
Drawing Suitability

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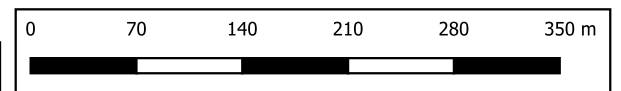
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Client
Bromley Council

Project Title				Hockenden Farm			
Drawing Title				Reference Zones			
Drawing Number		Project		Originator		Volume	
Drawing 2							
Original Size	Scale	Type	Role	Number	Sheet	Rev	
A3	1:2500	Ref. No	5216374	1 of 1	01		



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Note: 2020 utilised last pulse LIDAR DSM data as more likely to return ground level

LEGEND

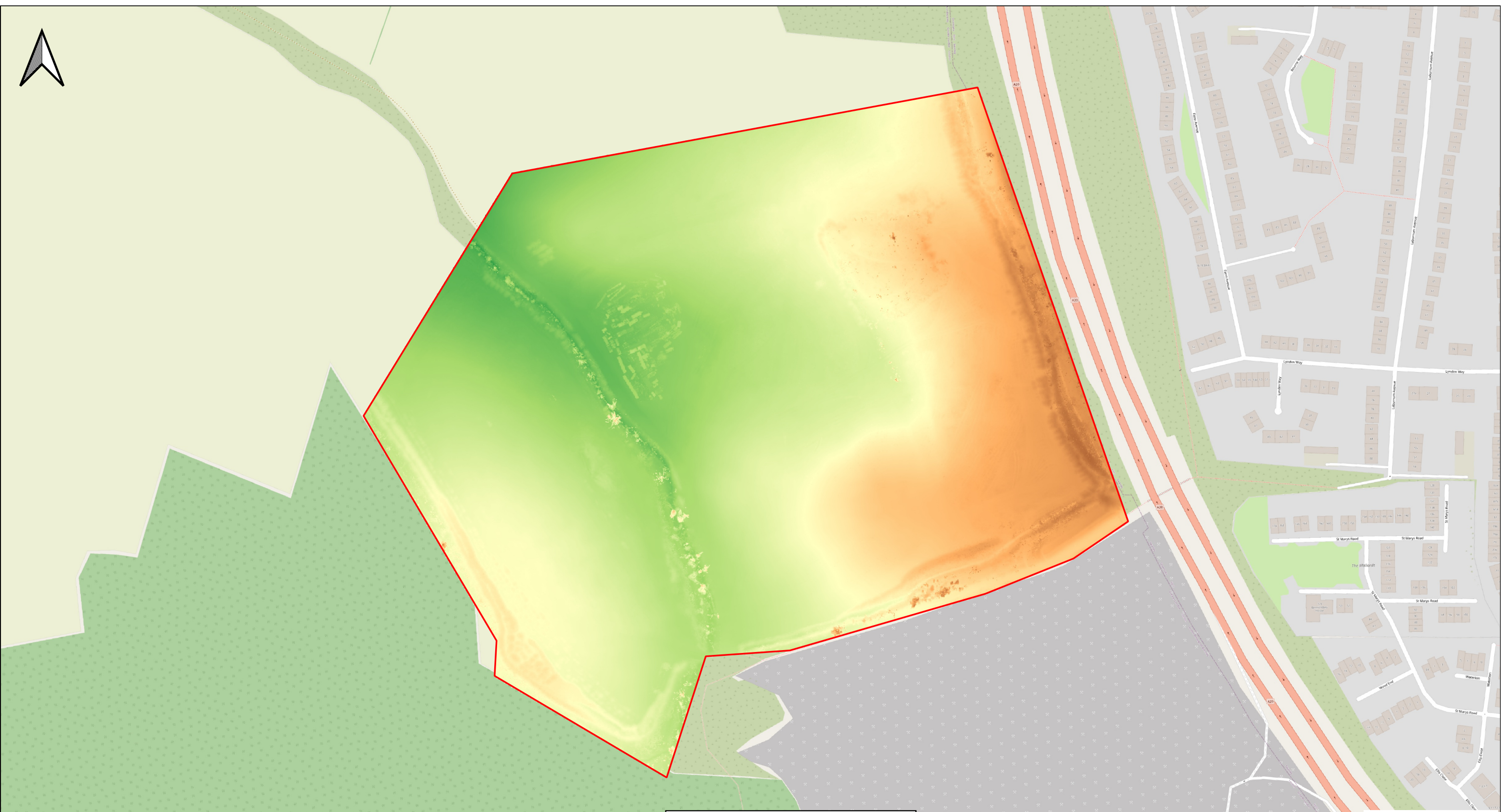
- Site Boundary
- Digital Surface Model
- Elevation (m)
- 80
- 51

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Presentation of LIDAR DSM data	Draft	01	DM	SM	Reviewed	Authorised	09/22

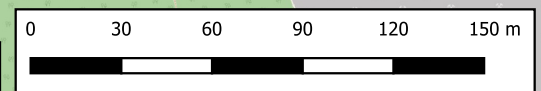
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Project Title		Hockenden Farm	
Drawing Title		LIDAR DSM Data (2009, 2015, 2018, 2020)	
Client		Bromley Council	
Drawing Number	Project	Originator	Volume
Drawing 3		Drawing 3	
Original Size	Scale	Type	Role
A3	1:5000	Ref. No	Number
		5216374	1 of 1
			Rev 01



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2022

LEGEND

- Site Boundary
- Digital Surface Model
- Elevation (m)
- 80
- 51

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
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Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Presentation of LIDAR DSM data						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Draft	01	DM	SM	Reviewed	Authorised	09/22

Drawing Suitability

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Project Title					
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LIDAR DSM Data (2022)					
Drawing Number					
Project	Originator	Volume			
Drawing 4					
Original Size	Scale	Type	Role	Number	
A3	1:2500	Project Ref. No	5216374	Sheet	1 of 1
				Rev	01