



Historic England

Geospatial Survey Specifications for Cultural Heritage





Summary

Geospatial survey forms an essential component of the conservation cycle, as well as providing a valuable source of base mapping for analytical projects. Whether supplying survey data to buildings curators, conservators, architects or archaeologists, surveyors need to know what makes survey work for cultural heritage. This specification is intended to act as a guide to both the user and supplier of geospatial survey data. It contains descriptions of the services expected and the performance requirements that can be used to ensure the successful management of geospatial survey projects.

As well as the specification clauses, within the text there is further information and references to more detailed guidance relating to the various techniques covered.

This document has been prepared by David Andrews, Jon Bedford and Gary Young. This edition published by Historic England, January 2024. All images © Historic England.

Front cover:

Orthophotograph derived from ground-based photography showing part of the West front of York Minster.

Please refer to this document as:

Historic England 2024 Geospatial Survey Specifications for Cultural Heritage. York. Historic England.

HistoricEngland.org.uk/images-books/publications



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Preface

The survey brief

The preparation of a brief for the supply of survey services based on the requirements of this specification will ensure the necessary communication between the information user (the client) and the information supplier (the surveyor) required for the successful application of geospatial survey.

Performance of geospatial survey in heritage documentation

In order to obtain geospatial survey fit for the purposes of heritage management, it will be necessary to consider not only the metric performance of measured data but also the required quality of work needed to act as both a record and an archive of the cultural heritage. The conventions of selection and presentation of measured drawing in architecture constitute a visual language that requires careful consideration. This specification contains both descriptions and illustrations of the required standard.

Use of the specification

This document is a description of the services and standards required for the supply of various types of geospatial survey. Sections 1 and 2 describe the general terms and performance requirements common to all services. Sections 3, 4, 5 and 6 contain standards specific to laser scanning, photogrammetric survey, measured building survey and topographic survey, respectively, while Section 7 covers presentation and delivery. A brief based on the accompanying OpenDocument text file *Geospatial Survey Specifications for Cultural Heritage: Project Brief Template* should be prepared in order to communicate the requirements of a particular project.

The use of any part of this specification without reference to the appropriate clauses of Sections 1, 2 and 7 plus the appropriate service description from Sections 3, 4, 5 and 6 is likely to result in an unsatisfactory product. For further information regarding the various techniques please refer to the text boxes and links to relevant guidance produced by Historic England and others. While it is hoped that this specification will be distributed widely and is available to anyone, its use is not a guarantee of the required results and it is recommended that, if in doubt, professional advice is sought.

1

General conditions

1.1 Introduction

The general conditions cover aspects of undertaking survey that are common to most geospatial survey activities carried out on historic sites. A separate project brief will contain the administrative and logistical aspects of a particular project plus reference to any variable clauses in the following sections.

1.1.1 Pertinent legislation

Contractors are to be aware of all current statutory requirements relevant to the contract for survey work. The contractor's attention is brought to:

- the [Ancient Monuments and Archaeological Areas Act 1979](#)
- the [Planning \(Listed Buildings and Conservation Areas\) Act 1990](#)
- [The Construction \(Design and Management\) Regulations 2015](#), introduced under the [Health and Safety at Work etc. Act 1974](#).

Copies of the above legislation can be obtained from [The Stationery Office](#).

Where the survey work occurs in countries other than England, the laws of that country will apply.

1.1.2 Client's guidance on matters concerning survey

Contractors are required to comply with the client's guidance on matters of safety and standards of work regarding the historic fabric.

1.2 The contract and other documentation

1.2.1 Contract

The contract will consist of the conditions noted in the project brief, this specification, plus any attached documents or diagrams.

1.2.2 Method statement

In response to a request for a quotation or invitation to tender, a method and resource statement is to be provided by the contractor. As a minimum it must include:

- the method proposed for providing survey control and the required detail
- the number and position of staff to be employed on the project, including the project leader
- the survey equipment, cameras, etc., to be used
- the access equipment to be used
- the lighting and electrical equipment to be used
- any proposed alternative survey methods and their performance
- the anticipated level of completion
- data retention and archiving arrangements
- the delivery schedule.

1.2.3 Risk assessment

A risk assessment must also be supplied with the quotation or tender. Known hazards will be highlighted in the project brief.

Further information

Clients should check the risk assessment and satisfy themselves that all foreseeable hazards have been addressed. It is the site owner's or lead contractor's responsibility to approve the risk assessment.

1.2.4 Site visits

The contractor may wish to visit the site to verify the requirements of the project and facilitate the production of the quotation or tender, the method statement and the risk assessment. Where access to land not in the client's care is necessary, assistance will be provided to secure the appropriate wayleaves.

1.2.5 Calibration certificates

Copies of up-to-date calibration certificates for all relevant equipment are to be supplied with the quotation or tender.

1.3 Contractual details

1.3.1 Completion of survey

The client will seek agreement with the contractor on the extent of cover, within the acceptable limits of tolerance and method (i.e. establishing any areas that require an alternative survey technique or that cannot be covered). Where obstructions to survey exist, the client will seek agreement about the possible extent of completion.

1.3.2 Right of rejection

The client reserves the right to reject the application of any proposed survey technique or submitted survey product.

1.4 Health and safety

1.4.1 Contractor's responsibilities for safety

The following requirements are included here as a guide, and contractors must ensure that all relevant safety regulations associated with the provision of survey on behalf of the client are complied with during the contract period. The contractor's attention is brought to the need for best practice in matters of safety.

1.4.2 Health and safety requirements

The client's health and safety requirements will be found in the project brief.

1.4.3 Health and Safety at Work etc. Act 1974

Under this Act employers have responsibilities to their employees and those affected by their work (e.g. members of the public and staff on site). Further information on this can be obtained from the [Health and Safety Executive \(HES\)](#).

Relevant publications can be ordered from [HSE Books](#).

1.4.4 Access equipment

Access equipment supplied or used by contractors or their agents must conform to the current safety standards. The contractor's attention is drawn to:

- [The Work at Height Regulations 2005](#)
- [Lifting Operations and Lifting Equipment Regulations 1998 \(LOLER\)](#), found in [Safe Use of Lifting Equipment](#)
- [Provision and Use of Work Equipment Regulations 1998 \(PUWER\)](#), found in [Safe Use of Work Equipment](#)
- [The Confined Spaces Regulations 1997](#), found in [Safe Work in Confined Spaces](#).

Full details, certification and nominated safety contacts on proposed access equipment, where relevant, are to be included in the method statement.

1.4.5 Electrical equipment

Where applicable, electrical equipment (the use of domestic/battery-operated equipment is not included) must meet the requirements of [The Electricity at Work Regulations 1989](#), found in the [Memorandum of Guidance on the Electricity at Work Regulations 1989](#).

1.5 Damage to site and fabric

There is a range of penalties and powers of prosecution under the provisions of the [Ancient Monuments and Archaeological Areas Act 1979](#) and the [Planning \(Listed Buildings and Conservation Areas\) Act 1990](#), should unauthorised work be carried out or damage caused to the building or monument.

1.5.1 Use of ground marks

The use of nails, permanent survey marks, etc., is subject to approval of the mark and its location. The insertion of any mark may require scheduled monument consent (SMC) and must not be done without the permission of the client and/or landowner.

1.5.2 Use of surface-mounted targets

Surface-mounted targets, such as for photogrammetric or laser scanning control, must be no larger than 200mm by 200mm and must only be fixed with an approved adhesive that will allow removal without damage to the surface. All targets must be removed at the end of the survey unless otherwise stated in the project brief.

1.6 Survey material supplied

1.6.1 Copyright

The copyright of all materials generated as part of the contract is to be transferred to the client unless stated otherwise in the project brief.

1.6.2 Retention of survey documentation

On request the contractor will make available to the client all materials used for the compilation of the required survey. This material must be retained by the contractor for a minimum of 7 years. As a minimum this material will include:

- field notes and/or diagrams generated while on site
- the raw and processed data used for the final computation of control
- registered laser scan data
- original and processed photogrammetric images
- computer-aided design (CAD) files for the final output.

If during this period the contractors want to change the format of this data archive, they are to seek the client's permission.

Further information

Retention of data by contractors is not a substitute for archiving. It is good practice to deposit survey data relating to heritage documentation with a suitably accredited archive service.

2

General performance and control of geospatial survey

2.1 General performance requirements

Geospatial survey techniques are required to deliver data that can be verifiably repeated.

This specification is intended for the generation of base survey data, located accurately in their true 3-dimensional (3-D) position, to which specific thematic input or attributes can be added if required.

2.1.1 Measurement performance

Measurement performance may be considered in terms of both accuracy and precision.

Definition of accuracy

Accuracy describes the closeness between measurements and their true values. The closer a measurement is to its true value, the more accurate it is.

Definition of precision

In surveying, precision is taken to describe the consistency with which a measurement or set of measurements can be repeated.

Repeatability of capture method

Data capture must be by a method that can be repeated, to the appropriate order of precision, by the use of similar equipment and suitably qualified personnel. Therefore, the proposed method must be fully and clearly described in the method statement.

Further information

For further information on measurement performance see the 2016 Historic England publication *Traversing the Past: The total station theodolite in archaeological landscape survey*.

2.1.2 Scale tolerance and point density

The precision of a survey is to be commensurate with the intended scale of presentation within the tolerances tabulated below. It is expected that surveyed data will allow repetition of a given measurement as presented on a plotted drawing within the following maximum tolerances when checked from the nearest control point.

Precision - Required maximum tolerance for precision of detail:

Scale	Acceptable precision (1 sigma)
1:10	±5mm
1:20	±6mm
1:50	±15mm
1:100	±30mm
1:200	±60mm
1:500	±150mm

Point density/rate of capture - Required distribution of measured points:

Scale	Point cloud	Digitising *	Field survey †
1:10	≤1mm	1–15mm (max. 0.25m)	2–30mm (max. 0.5m)
1:20	≤2.5mm	2.5–30mm (max. 0.5m)	5–60mm (max. 1m)
1:50	≤5mm	5–50mm (max. 1m)	10–100mm (max. 2m)
1:100	≤15mm	15–100mm (max. 1.5m)	20–200mm (max. 3m)
1:200	≤30mm	30–300mm (max. 2.5m)	50–600mm (max. 5m)
1:500	≤75mm	75–750mm (max. 5m)	0.1–1.5m (max. 10m)

* From photogrammetric model, laser scan point cloud or ortho-image.

† For example, by total station theodolite (TST) or global navigation satellite system (GNSS).

In both cases where lines appear straight or detail is sparse, the interval may be increased up to the maximum indicated in parentheses.

Further information

Scale tolerance can be specified in terms of standard deviation (σ) or root mean square error (rmse). Standard deviation is based on the assumption that random errors will have a normal distribution around the mean. One standard deviation means there is about a 68% probability that all measurements will have errors not greater than the mean value. For more information on this subject see the 2014 Royal Institution of Chartered Surveyors (RICS) guidance note *Measured Surveys of Land, Buildings and Utilities, 3rd edition*.

2.1.3 Completeness of survey

The detail and precision with which survey data are collected must be commensurate with the required scale across the entirety of the survey, whatever the method or methods employed.

Survey coverage, with regard to both the extent of the survey and the completion required within that extent, is to be determined by the needs of the project. Elevations and sectional elevations will be complete to full height unless otherwise specified. Any requirement for field completion of obscured areas by another method will be by agreement between the contractor and the client.

2.2 Control of survey

2.2.1 General requirements

The control for all survey projects must be reliable, repeatable and capable of generating positions within the required tolerances. The method and equipment used to establish survey control networks is at the discretion of the contractor; however, the proposed methods and equipment must be detailed in the method statement. The contractor is to establish a hierarchical network of coordinated and levelled permanent, semi-permanent and temporary survey stations to control the survey and to provide references for future surveying and engineering works.

All coordinate and level values generated must be expressed in metres to 3 decimal places and presented in the order of easting (X), northing (Y) and height (Z).

2.2.2 Hierarchy of control

The primary survey control network is to consist of permanently and semi-permanently marked stations and should, wherever practical, wholly enclose the detail survey area. If possible, the distance between primary stations should not be less than 100m and not more than 300m. Additional secondary control networks consisting of semi-permanent control stations are to be established from the primary control such that the spacing between adjacent primary and secondary control stations is not less than 50m and not more than 300m. Tertiary control networks and spur stations required for mapping purposes may be established from secondary control stations at the contractor's discretion.

Survey control stations or targets are to be named using a letter prefix to designate the type, and a three-digit numerical value to identify the individual target. For example, 'P001' is the first primary station:

Type	Prefix	Description
Primary	P	Primary control is the highest order, most secure control on the site, e.g. the highest accuracy GNSS baseline present or the local site datum
Secondary	S	Secondary control is established via observations to the primary control, e.g. a traverse based on a primary baseline
Tertiary	T	Tertiary control is established via observations to the secondary control, e.g. a sub-traverse or spur station based on a secondary baseline
Photogrammetric target	PH	Targets coordinated for the purpose of controlling photogrammetry, e.g. butterfly targets
Laser scanning target	LS	Targets coordinated for the purpose of controlling laser scanning, e.g. chequer boards or tilt and turn targets
Aerial mapping target	A	Targets coordinated for the purpose of controlling drone-based aerial mapping, e.g. chequer boards

2.2.3 New control network

Survey grid

Where the establishment of a new control network is required, it is to be related to Ordnance Survey National Grid (OSGB36) and/or a local plane grid derived from OSGB36. The network must be derived from GNSS observations related to the Ordnance Survey National GNSS Network Active Stations and transformed to OSGB36 using Ordnance Survey National Grid Transformation OSTN15.

A local grid origin is to be established in such a way as to ensure that the eastings will not match the northing values anywhere on the site and that all values will be positive. The origin used should ensure that local grid coordinates will not be confused with National Grid values.

Where it is not possible/required to relate the local grid to the Ordnance Survey National Grid, a local grid will be established such that the orientation is either as close to Ordnance Survey National Grid north as is practicable or parallel to the principal axis of the historic building or monument being surveyed.

Level datum

The level datum to be used is Ordnance Datum Newlyn (ODN) derived by GNSS observations related to the Ordnance Survey National GNSS Network Active Stations and transformed to ODN using Ordnance Survey National Geoid Model OSGM15.

A local arbitrary datum may be required on occasion; when this is the case, full details of the site benchmark are to be included with the permanent survey mark witness diagrams.

Further information

Further information

For further information on the Ordnance Survey National Grid see their 2020 publication [A Guide to Coordinate Systems in Great Britain](#).

2.2.4 Existing control network

Where a previously defined site control network exists, the necessary information will be supplied by the client to enable the re-occupation of permanently marked points. This will include a full listing of 3-D coordinates and witness diagrams. During re-occupation and re-observation, the contractor is to:

- locate each marked point, by setting out from local detail or coordinates if necessary
- visually check for disturbances and undertake such observations as necessary to confirm their integrity
- revise witness diagrams as necessary and record the date of inspection.

Where discrepancies are found, the client is to be contacted to agree any necessary variations.

2.2.5 Vertical control using spirit levelling

Required accuracy/misclosures

Where a high standard of accuracy is required, one primary control station is to be fixed in level and the remainder derived by spirit levelling. When using a level to observe survey control, the level run must always close internally either in a loop or by double levelling. Where a lower standard of accuracy is specified, GNSS or traverse-derived level values may be accepted.

Spirit level run misclosures are to be assessed using Clark's formula:

- for level runs less than 1km, $E = 0.005 \sqrt{N}$ (where N = number of set ups)
- for level runs greater than 1km, $E = 0.012 \sqrt{D}$ (where D = traverse length in kilometres).

When using digital levels, the maximum misclosure should be approximately half the above values. If not, it is likely that a gross error has been made and further checks will be needed.

Control observations and measurements

Closed levelling circuits from the required site datum point will connect survey control stations, and the resultant relative heights will be used to determine the absolute level values.

2.2.6 Horizontal and vertical control using traversing

Required accuracy/misclosures

Control networks are to have a linear accuracy of better than 1/20,000 prior to any adjustment being made.

The maximum distance error between adjacent permanent survey control stations must not exceed $5\text{mm} \pm 5$ parts in 1,000,000 or 10mm, whichever is the greater.

Vertical differences in height between adjacent stations, when measured in the forward traverse direction, will agree to better than $\pm 20\text{mm}$ compared with the vertical difference in height when measured in the reverse traverse direction, or when checked by spirit levelling methods.

Control observations and measurements

The contractor is to undertake and record survey observations and measurements sufficient to enable the reduction and computation of coordinates to the required accuracy standards.

Each new control network must start and finish with observations to control stations of a higher network order.

A minimum of three rounds of observations and measurements is to be taken on each face of the instrument to ensure that unambiguous data are collected, and that redundant data can be excluded without compromising the validity of the computations.

All horizontal control observations are to be made to prisms optically or laser plumbed above the survey control mark.

Distances between adjacent survey control stations must be measured in both directions in order to eliminate centring errors.

Sufficient observations and measurements to enable computation of absolute level values for each secondary and tertiary survey station are to be taken while ensuring that unambiguous data are collected and that redundant data can be excluded without compromising the validity of the computations.

Adjustments carried out to the observed network, including type and method of adjustment used and the results of transformations, are to be detailed in the final survey report.

2.2.7 Horizontal and vertical control using GNSS

Except where otherwise defined in the project brief, all horizontal and vertical control is to be related to the Ordnance Survey National GNSS Network as described in Section 2.2.3. For guidance on good practice refer to the 2010 RICS guidance note *Guidelines for the Use of GNSS in Land Surveying and Mapping, 2nd edition*.

General GNSS observation requirements

One of three orders of GNSS observation is to be used depending on the accuracy requirements and the nature of the project. In general, this will be the third order unless otherwise stated in the project brief.

Observation times and sources of control are detailed below:

Order	Observation period cloud	Source control
First	Minimum 4 hours static	Minimum 4 Ordnance Survey active stations
Second	Minimum 20 minutes static	Minimum 2 first order stations
Third	As described below for network RTK	Network RTK

For all GNSS observations, dual-frequency survey-grade GNSS receivers are to be used. For network real time kinematic (RTK) observations, receivers should receive signals from the GPS and GLONASS constellations as a minimum.

Should it be required by the project brief, the contractor will submit a detailed plan, as part of the method statement, for all GNSS control network observations for approval prior to the commencement of any work. This plan is to detail the approximate locations of control stations, a network diagram and the proposed schedule of occupation, including duration and observation periods.

GNSS control stations that are intended to measure height are to be located with a substantially clear view of the sky and not close to buildings or other structures that may introduce multipath effects. A minimum of five satellites must be observed for the full observation period, with a minimum elevation mask of 13°. Geometric dilution of precision (GDOP) values must not exceed 5 for the entirety of the observation period.

GNSS baselines are to be computed using National Geodetic Survey (NGS) antenna models. Baselines should be computed using post-processed, in preference to broadcast, ephemeris.

Baselines are to be post-processed and adjusted to the source control stations with a least squares network adjustment.

Receiver independent exchange format (RINEX) data for any post-processed GNSS observations are to be retained and supplied on request. All baseline computations and network adjustments are to be provided in digital form with the survey report.

Network RTK observations are to be made using at least three periods of 3-minute observations separated by at least 20 minutes. If the difference between one of the three periods and any other exceeds 30mm, it will be discarded from the results. Network RTK stations are not to be established in isolation. Each station must be connected by spirit levelling to at least one other station. For further guidance see [The Survey Association \(TSA\) 2015 Guidance Notes for GNSS Network RTK Surveying in Great Britain](#).

Transformations

All transformations from GNSS-derived ETRS89 coordinates to OSGB36 are to be carried out using the OSTN15 and OSGM15 transformations, licensed by the Ordnance Survey.

2.2.8 Survey marks

Permanent or temporary ground marks are to be as non-invasive as possible and preferably existing detail should be used. The client must approve the type and location of any permanent mark before insertion. In some cases, SMC will be required.

The type of mark to be used will depend on:

- the project brief
- site limitations (including any requirement for SMC)
- ground conditions
- landowner restrictions.

For further details on obtaining SMC in England see [Historic England's guidance](#).

Permanent stations

Permanent stations must be one of the following types:

- bolt
- earth anchor
- stainless steel survey nail
- cut mark or punch mark.

Bolts will be installed by drilling and fixing with an epoxy resin-type adhesive into a stable and permanent structure (not asphalt or kerb stones).

Temporary stations

The type of mark used for temporary stations may be any of the following, depending on the above criteria:

- wooden peg or stake driven flush to the ground and with a painted top
- stainless steel survey nail
- cut mark or punch mark
- indelible pen mark on concrete surface.

Temporary survey stations are expected to remain usable for a minimum period of 3 weeks after delivery of the survey.

Further information

Even the insertion of nails may require SMC and, in all cases, they must only be driven into a suitable material, for example earth, gravel or a mortar joint, not historic floorboards, etc. Contractors are reminded that there is a range of penalties and powers of prosecution under the provisions of the [Ancient Monuments and Archaeological Areas Act 1979](#) and the [Planning \(Listed Buildings and Conservation Areas\) Act 1990](#) should unauthorised work be carried out or damage caused to the building or monument.

Landowners' permission

The permission of landowners must be obtained prior to the establishment of marks. The landowner must be consulted on the installation of all types of mark. Earth anchors are to be buried to a depth agreed with the landowner (normally 0.1m below ground level). Wooden pegs must be driven to ground level; they must not be left protruding above ground level as a trip hazard.

Where any form of ground-penetrating station mark is to be established, with the exception of small nails or bolts, appropriate checks for underground services must be undertaken prior to installation. For marks penetrating more than 0.5m, a search must be made with all appropriate utility service providers. Where temporary pegs are installed, they must not penetrate the ground to a depth of more than 0.2m.

2.2.9 Use of targets on historic fabric

Where survey targets are to be applied to historic fabric, a suitable non-marking, non-destructive method of adhesion is to be used. This must allow for the removal of the targets without damage to, or marking of, the fabric. Details of the proposed method of adhesion are to be included in the method statement for the survey. The client reserves the right to refuse application if the proposed substance is deemed to be unsuitable for historic buildings or monuments. All targets must be removed before the commission is completed; any targets remaining after completion will still have to be removed at the contractor's expense.

Surface-mounted targets must be no larger than:

- 60mm by 40mm for photogrammetric control
- 200mm by 200mm for laser scanning control.

2.2.10 Survey report

A detailed survey report is to be provided, including the:

- site name and location
- project reference number
- dates of current survey
- site reconnaissance details, including conditions at time of survey (e.g. weather)
- survey personnel who formed the site and processing teams
- field equipment used
- all GNSS observations and survey network analyses, adjustments and output reports for establishing site control relative to Ordnance Survey National Grid (OSGB36) and ODN, where applicable
- all horizontal and vertical control survey network analyses, adjustments and output reports
- coordinate schedule, including all control and target coordinates
- witness diagrams of all the control stations (see Section [2.2.11](#))
- quality assurance/accuracy compliance
- equipment calibration certificates
- survey field records.

2.2.11 Witnessing of stations

Full witness diagrams are to be provided with the survey report for all permanently marked control stations.

Witness diagrams must include:

- coordinate values to 3 decimal places as eastings (X), northings (Y) and height (Z)
- a sketch diagram and dimensions to at least three points of hard detail
- a written description of the mark
- a photograph of the location.

3

Standard specification for the collection and registration of laser scan data

3.1 Definitions

3.1.1 Laser scanning

Terrestrial laser scanning is defined as the use of a ground-based device that employs a laser to measure 3-D coordinates automatically on the surface of an object in a systematic order and at a high measurement rate. For the purposes of this document, close-range and terrestrial laser scanners will be referred to jointly as laser scanners.

The specification of airborne lidar survey is beyond the scope of this document.

3.1.2 Point cloud

Any laser scanning system generates a point cloud that can be regarded as the raw product of a laser scan survey. A point cloud is a collection of XYZ coordinates in a common coordinate system that portrays to the viewer an understanding of the spatial distribution of a subject. It may also include additional information, such as return intensity or even colour values. Generally, a point cloud contains a relatively large number of coordinates compared with the volume the cloud occupies, rather than a few widely distributed points. Some instruments also provide more fundamental information on the full reflectance of the laser pulse (known as full-waveform scanners).

3.1.3 Scan registration

Scan registration is the process by which the laser scan data is fixed relative to the site survey control in line with the specified grid and datum requirements.

Targets located in a defined coordinate system will usually be used to register multiple scans together. Positioned using a TST, they provide additional checks on the geometric quality of the scan data and enable the transformation of the complete dataset to a common coordinate system.

It is also possible to register laser scan data together without the use of any external reference targets. Known as ‘cloud-to-cloud’, this target-less registration approach relies on suitably dense point clouds being captured with appropriate overlap between adjacent scans to enable sufficient matching points to be derived.

Further information

For further information on laser scanning, see the 2018 Historic England publication *3D Laser Scanning for Heritage: Advice and guidance on the use of laser scanning in archaeology and architecture*.

For an introduction to airborne lidar and its application to the historic environment, see the 2018 Historic England publication *Using Airborne Lidar in Archaeological Survey: The light fantastic*.

For more technical details, see the 2023 RICS professional standard *Earth Observation and Aerial Surveys, 6th edition*.

3.2 Laser scan survey

3.2.1 Method statement

The method statement, in the case of laser scanning, should as a minimum include the:

- technical specifications of the proposed scanning system(s)
- proposed point density of the scans
- proposed targeting and registration approach
- location of potential data voids and how they might be in filled.

3.2.2 Equipment calibration

All laser scanners must be serviced and calibrated In line with the manufacturer's recommendations prior to commencing any work. Uncalibrated equipment will not be used under any circumstances.

The contractor is to provide copies of appropriate certification, as required, in the survey report.

3.2.3 Health and safety

Laser light can, in some cases, be harmful, and therefore suitable precautions must be taken to ensure the safety of both the scanner operator and any members of the public that may encroach within the area of scanning.

Systems that use Class 1, 2 and 3R lasers operate within acceptable eye-safe limits and therefore can be used for survey purposes at publicly accessible sites. Systems that use Class 3B or 4 lasers operate beyond recognised eye-safe limits and therefore must not be used for any survey-related activity at any publicly accessible site. Signs warning visitors that scanning lasers are in use will be displayed in each scan area. These are mandatory for Class 2 and 3R laser scanning systems and optional for those using Class 1 lasers.

3.2.4 Weather

Laser scanning should not be undertaken during inclement weather (e.g. rain, snow, fog, mist, strong winds), where the quality of data will be affected by the returns and scattering from droplets, refraction of the measurement beam, or a lack of balance in the tilt compensator.

3.2.5 Accuracy of control

Laser scan targets are to be coordinated to a 3-D accuracy of:

- (a) either $\pm 3\text{mm}$
- (b) or as stated in the project brief.

The scanner must be set up in a stable position while operating to ensure minimum movement and distortion within each scan.

All survey stations that are used to measure targets for the laser scanning will be located adjacent to the area where the laser scan data are to be collected and no more than 100m apart.

3.2.6 Control targets

The type of targets used, their distribution and the method of laser scan observation to them are all discretionary. They must, however, be:

- not so large that they obscure important fabric detail
- positioned away from the principal surface being surveyed
- not attached to any important historic fabric
- arranged so as to minimise data voids in the point cloud
- removed at the end of the survey, either on completion of site work or after successful registration is achieved.

A description of the targets and proposed registration approaches must be included in the method statement.

3.2.7 Point density

The required point density and precision is defined below for the scale specified in the project brief:

Type	Scale	Minimum point density	Precision of measurement
Close range	1:5	0.5mm	±0.5mm
	1:10	1.0mm	±1.0mm
Terrestrial	1:20	2.5mm	±2.5mm
	1:50	5.0mm	±5.0mm
	1:100	15.0mm	±15.0mm

Further information

Scanning at a higher density than the accuracy of the measurement may generate an impressive dataset but will result in a high level of noise within the resulting point cloud. The smaller the distance between points, the more likely it is that an object will be recorded. So as a general rule the point density should be at least half the size of the smallest feature to be recorded within the scan. The width of the measurement beam must not be greater than double the effective point density. For most instruments point density during the scanning process depends on range, so it is not normally possible to maintain a constant point density over the entire subject.

3.2.8 Data voids

Voids caused by moving obstructions, such as cars and pedestrians, will not be acceptable unless it is impossible to restrict public access into the scan area. Any obstructions that will potentially occlude areas in the scan will be highlighted in the method statement. The use of multiple scans or alternative measurement technologies for potentially infilling the data void may also be proposed.

3.2.9 High level coverage

Methods used to achieve high level coverage must be described in the method statement alongside any proposed mechanisms for stabilising the platform and laser scanner.

3.3 Registration

3.3.1 Registration methods

Scan registration must be performed using:

- control targets
- or a target-less 'cloud-to-cloud' approach
- or simultaneous localisation and mapping (SLAM) techniques controlled by targets
- or a combination of the above.

Whichever method is employed the registration accuracy stated below must be met.

3.3.2 Registration accuracy

- Each laser scan will be required to fit to the survey control within 5mm.
- Target registration must demonstrate residuals no greater than 5mm.

Where registration is to be undertaken using solely targets, a minimum of four coordinated targets is required, and they will be positioned to ensure good spatial geometry.

Cloud-to-cloud registrations must be referenced to the site control network using a minimum of four coordinated targets.

3.3.3 Registered scan data requirements

All laser scans are to be registered to the site control network, unless otherwise agreed. Preferably the complete scan project will be registered together. If, however, a scan project is too large then the scan registration may be broken into sub-projects.

3.4 Provision of point cloud data

3.4.1 Deliverables

As well as any derived products noted in the project brief, the following deliverables may be required:

- raw and registered scan data, in the formats as described in Section 3.4.5
- metadata, as described in Section 3.4.6
- a survey report, including as a minimum
 - a diagram showing the approximate scan positions
 - a diagram showing the location of all targets
 - a listing of 3-D coordinates of all control points/targets
 - a registration report showing the overall accuracy of the laser scan survey.

3.4.2 Colour information

The project brief will specify whether, alongside the laser intensity value, red-green-blue (RGB) colour information, acquired on a per point basis at each scan position, is required.

Further information

Almost all laser scanning systems provide intensity information alongside the XYZ coordinates for each 3-D point that comprises the point cloud. Most also use an imaging sensor, either located within the scanner or attached externally, to acquire separate colour imagery of the scan scene from which an RGB value for each point can be assigned. Depending on the scanner the capture of colour information can add substantially to the scanning times on site.

3.4.3 External imagery

The project brief will specify whether panoramic imagery acquired with a separate camera, the optical centre of which has been aligned with the laser scanner measurement centre, is required.

3.4.4 File naming convention

File names for laser scan datasets are to conform to the standard naming convention as specified in Section 7.

3.4.5 File formats

The raw scan data (as collected by the scanner before processing) and any later registered versions will be delivered in both their proprietary (manufacturer-specific) format and in the non-proprietary E57 data exchange format.

3.4.6 Metadata

Metadata (information relating to the captured scan data) must be supplied with all raw scan data and as a minimum will include the:

- raw data file name
- project reference number
- scanning system used, including serial number
- average point density on the subject (with reference range)
- total number of points
- date of capture
- site name
- contractor name.

This metadata can be provided either in digital form for each individual scan or incorporated within each scan data file, ensuring that the required data fields are correctly included and can be retrieved using common post-processing software.

The project brief will specify whether the metadata is to be supplied and whether a standard template is to be used.

Further information

It is recommended that the provision of metadata is a requirement of the contract and that a standard template, such as that published by the [Archaeology Data Service](#), is used.

4

Standard specification for photogrammetric survey

4.1 Definitions

4.1.1 Photogrammetric survey

Photogrammetric surveys are those where overlapping image sets are used together with survey control to produce a 3-D representation of the subject from which the required output is generated. Products may be orthophotographs, scaled drawings digitised from them, digital surface/terrain models (DSM/DTM) or other vector products derived from them (such as contour lines).

4.1.2 Orthophotographic survey

An orthophotograph is a digital image that has been corrected for lens distortion and scale errors arising from both camera tilt and depth displacement. See [Fig. 4.1](#) and [Fig. 4.2](#).

Further information

For further information on photogrammetry and its application to the historic environment see the 2017 Historic England publication *Photogrammetric Applications for Cultural Heritage: Guidance for good practice*.

Rectified photographic surveys are defined as those where single photographs are taken with the image plane of the camera approximately parallel to the principal plane of the object and then further digitally corrected to remove scale errors arising from camera tilt. Rectified photography is now rarely employed because of the ease of producing orthophotographs and the fact that they are more accurate.

Figure 4.1:
Orthophotograph derived
from ground based
photography.

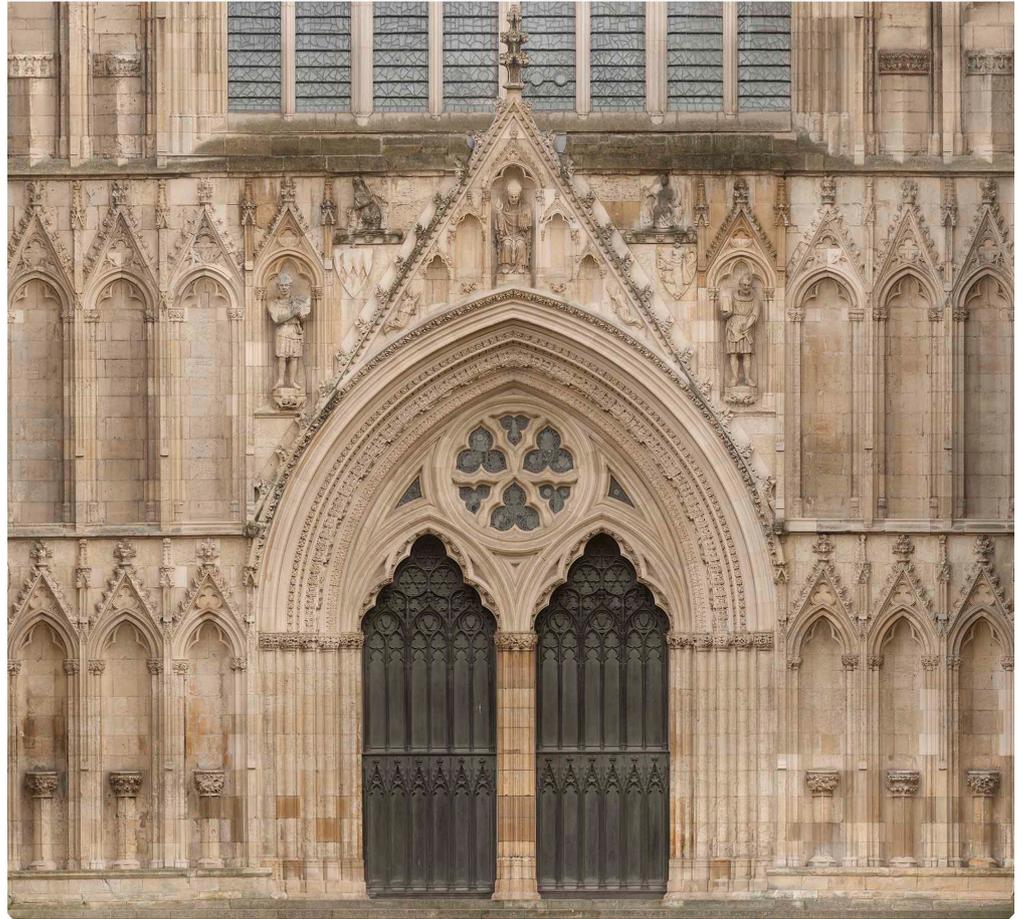


Figure 4.2:
Orthophotograph
derived from drone aerial
photography.



4.2 Control for photogrammetric survey

4.2.1 Accuracy of control

Building survey

Image control points are to be provided to a 3-D accuracy of:

- (a) either $\pm 3\text{mm}$
- (b) or as stated in the project brief.

Topographic or landscape survey

Image control points are to be provided to a 3-D accuracy of:

- (a) either $\pm 30\text{mm}$
- (b) or as stated in the project brief.

A listing of the 3-D coordinates is to be included in the survey report.

Where aerial imagery is used in support of topographic survey (to provide a DSM/DTM), the aerial control must be on the same coordinate system as the topographic survey.

4.2.2 Targets

For photogrammetric surveys of buildings and structures, a minimum of four coordinated control points, directly observed in the field, is to be provided for each elevation. Where practicable, targets placed on the fabric are to be used (see Sections 1.5.2 and 2.2.9) and must:

- be no larger than 60mm by 40mm
- no thicker than 0.5mm
- have a matt, non-reflective surface finish.

Where photogrammetry is combined directly with 3-D laser scanning, for example to provide high-level infill, coordinated targets or detail points (see Section 4.2.3) that are visible in both sets of data must be used.

For aerial photogrammetry topographic or landscape surveys, a minimum of eight coordinated control points, directly observed in the field, will be provided. Where practicable, targets are to be used and must:

- be large enough to be easily identified at the required ground sample distance (GSD)
- have a matt, non-reflective surface finish.

4.2.3 Use of detail points

Where targets cannot be used, it is acceptable to use unambiguous points of detail. A sketch diagram or annotated image showing the location of each point is to be included in the survey report. Detail points must be easily identifiable and must not be taken from the extreme edges of the subject. Whether it will:

- (a) not be acceptable
- (b) or only be acceptable where absolutely essential
- (c) or be necessary

solely to use detail points for image control will be stated in the project brief.

4.2.4 Check points

As well as control points, a number of check points, which are not used in the adjustment, are required to verify the accuracy of the reconstruction. For building elevations, a minimum of 50% additional points is required (e.g. if four control points are used, a minimum of two check points is needed); for topographic surveys, a minimum of 25% additional check points is required (e.g. 12 control points require at least three check points). The variations between measured and reconstructed point values are to be included in the survey report.

4.3 Photogrammetric survey

4.3.1 Cameras

Details of proposed cameras and lenses are to be included in the method statement. Use of a calibrated lens with a fixed focal length is:

- (a) either essential
- (b) or not essential

as stated in the project brief.

Further information

For best results the highest quality possible combination of sensor and lens should be used. Cameras should ideally have a sensor array with at least 20 million pixels and each pixel should be a minimum size of 6 microns. High pixel counts on small sensors can lead to noisy images. See the 2017 Historic England publication *Photogrammetric Applications for Cultural Heritage: Guidance for good practice*.

4.3.2 Digital image requirements

Images are to be captured in RAW format where possible, and these files must also be supplied as TIFF versions. Colour imagery is to be white balanced for either daylight or artificial illumination, as appropriate.

In certain situations, the use of JPG files will be acceptable if stated in the project brief.

The required colour space is the Adobe RGB (1998) ICC colour profile. A standard colour chart and/or grey card is to appear in at least one of the images per subject area to provide guidance on colour balancing prior to output.

4.4 Image acquisition

The whole of the subject must be covered by overlapping imagery.

4.4.1 Imagery arrangement

Images must be acquired to provide the following minimum overlap:

- between adjacent images of at least 60%
- between adjacent strips of images of at least 40%.

4.4.2 Ground sample distance

The GSD for each image is to be the maximum as tabulated below:

Output scale	GSD
1:10	0.5mm
1:20	1mm
1:50	2mm
1:100	4mm
1:200	10mm
1:500	20mm

Further information

GSD is the size in the real world of that part of the subject represented by one pixel of a digital image. It is a function of focal length, camera to subject distance (or flying height) and pixel size.

$$\text{GSD} = (H/f) \times p$$

where H = camera to subject distance or flying height, f = focal length, and p = pixel size (sensor size in one axis divided by pixel count in same axis).

4.4.3 Use of oblique imagery

In general photography is to be taken square-on to the subject, but oblique and/or convergent imagery will also be required to ensure suitable geometry for successful reconstruction and complete coverage of all elements of the subject.

4.4.4 High-level coverage

Where the subject to be surveyed is of a significant height, imagery must still be taken within the stated tolerances for overlap and GSD as outlined in Sections 4.4.1 and 4.4.2. Aerial imagery captured using a drone will normally be the most efficient way of achieving this, but if this is not possible the use of access equipment is:

- (a) not essential
- (b) or at the contractor's discretion
- (c) or essential

as stated in the project brief.

4.4.5 Use of drones

All image acquisition undertaken using a drone must conform to current UK aviation law, as detailed in [The Air Navigation Order 2016](#). See also the 2022 Civil Aviation Authority publication *Unmanned Aircraft System Operations in UK Airspace – Policy and guidance CAP 722, 9th edition, Amendment 1*.

Full details of any proposed use of a drone must be included in the method statement, along with both a pre-site survey and a risk assessment that considers all associated risks and how these will be mitigated.

Further information

For further information on the acquisition of aerial imagery for photogrammetry, particularly from conventional aircraft, see the 2023 RICS professional standard [Earth Observation and Aerial Surveys](#).

4.4.6 Completeness of survey

Survey data obtained using photogrammetric techniques are to be as complete as possible.

The client will endeavour to provide a clear and unobstructed view for photography prior to survey commencing, but where obstructions prevent the use of images it will be acceptable to omit detail that cannot be clearly seen. Field completion by another method may be required.

Additional oblique aerial imagery at approximately 45° off-nadir (to be used for infill under isolated trees, for example) will:

- (a) either be required
- (b) or not be required

as stated in the project brief.

4.5 Photogrammetric processing

All photogrammetric processing work is to be carried out using dedicated photogrammetric software utilising overlapping imagery. The choice of software and method is discretionary but must be outlined in the method statement. Material generated must be within the stated tolerances and meet the specified standard for vector drawing extraction or orthophotograph production.

4.5.1 Accuracy of restitution

The accuracy results for all processed models are to be recorded and provided in the survey report.

4.5.2 Accuracy of processing

For the production of line drawings, digitised points must be within the accuracy figures noted below; the standard relates to the accuracy of the final line width of the vector data generated.

For output at standard scales, using a 0.18mm line width, these are:

Output scale	In reality
1:10	2mm
1:20	4mm
1:50	9mm
1:100	20mm
1:200	40mm
1:500	90mm

4.6 Vector drawing content

See Section 5 for details of any vector drawing requirements.

4.7 Orthophotographic processing

The choice of equipment, software and method for providing the required survey are discretionary, but they must be outlined in the project method statement.

4.7.1 Accuracy of processing

All overlapping images are to be processed so that the residuals obtained during the reconstruction procedure enable the generation of survey data that are commensurate with the required output resolution (GSD).

4.7.2 Digital surface model

Unless otherwise stated in the project brief, DSM point spacing is to be:

Output scale	Maximum DSM point spacing
1:10	1mm
1:20	5mm
1:50	10mm
1:100	10mm
1:200	20mm
1:500	40mm

4.7.3 Mosaic generation

The orthophotograph mosaic is to be generated so that the joins between images are not visible in the final output. Seam lines will be edited if necessary. Colour balance must be consistent and any distinct shadows in recessed areas are to be digitally removed.

4.7.4 Orthophotograph output resolution

The final output scale is to be as specified in the project brief. Unless stated otherwise in the project brief, the maximum GSD is to be:

Output scale	Maximum GSD
1:10	0.25mm
1:20	1mm
1:50	2mm
1:100	5mm
1:200	10mm
1:500	25mm

4.7.5 Presentation of orthophotographs

All orthophotographs are to be attached to an AutoCAD .DWG file and correctly georeferenced to the control coordinate system.

The images are to be supplied as:

- (a) either TIFF files
- (b) or geoTIFF files

as stated in the project brief. Where geoTIFF is specified, a separate world file for each image is also required.

5

Standard specification for measured building survey

5.1 Measured building survey

5.1.1 Definition of measured building survey

For the purpose of this specification ‘measured building survey’ is defined as the supply of geospatial survey data pertaining to buildings and presented as plans, sections, sectional elevations and elevations.

5.2 Description of products

The survey is to be supplied as a CAD drawing in the form of plans, sections, sectional elevations and elevations presented graphically (i.e. using lines and symbols). Where necessary, the graphical data will be supplemented by text annotation (e.g. description of floor covering and material, height information) as shown in [Fig. 5.1](#). The correct use of line type, line weight ([Fig. 5.2](#)) and layers (see [Appendix 5.1](#) for layer names) is essential in order to present the drawing elements in accordance with architectural convention. The building subject is to be presented using an orthogonal projection (i.e. the plan, section, sectional elevation or elevation is to be shown as a parallel projection onto a horizontal or vertical reference plane, as described below).

5.2.1 Plan

A view of the structure as seen in a horizontal reference plane defined by the cut line. The plan will show information above and below the reference plane unless this information is covered on another plan. The cut line will reveal full architectural detail, deformation or displacement both at the height of the cut and also above and below it. It will be made as informative as possible by cutting across door and window openings.

5.2.2 Section

A view of the internal space of the subject showing only those elements (including the thicknesses of walls) cut by a vertical reference plane (Fig. 5.3a).

5.2.3 Sectional elevation

A view of the internal space of the subject as seen from a plane defined by the cut line or section line and showing all the detail revealed by that view (Fig. 5.3b and Fig. 5.3c). Major structural components not visible (e.g. hidden from view or in front of the cut line) may need to be shown by use of a dashed line.

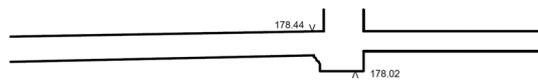


Figure 5.3a:
Profile or section -
1:50 level of detail.

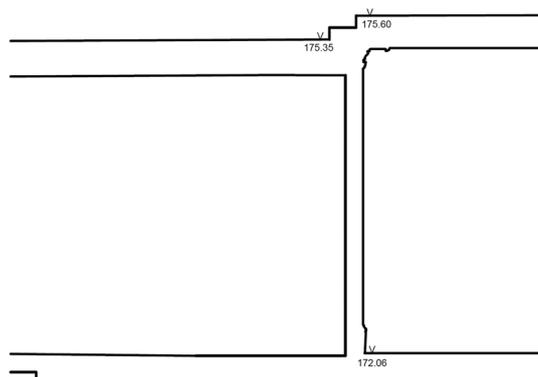


Figure 5.3b:
Sectional elevation -
1:50 level of detail.





Figure 5.3c: Sectional elevation - 1:20 level of detail.

5.2.4 Elevation

A view of a façade or wall of the subject as an orthographic projection.

Further information

A plan (see [Fig. 5.1](#) and [Fig. 5.2](#)) is a convention for showing the horizontal extent of a building. A cut line is required to show the walls of the building. The convention is for the cut line to follow the height of a line between the hip and shoulder height of a person standing. The cut line is not simply a height at which the plane of projection is set: it can vary. Clients are advised to specify closely a desired cut line if there is ambiguity over the suitable height of the line (e.g. at changes in floor level or where buildings are built into a slope). A section line can be taken anywhere through the building (see [Fig. 5.4](#)). The section line defines a plane of projection for the preparation of an elevation view. Section lines must be clearly defined in terms of position, extent and direction of view. They can be adjusted to include or exclude features (e.g. chimneys), but the line must remain parallel to the original plane. The exact position of the section lines needed to show the required aspects of the building when projected as a sectional elevation should be clearly delineated on sketch diagrams to accompany the project brief. Sections and sectional elevations are different (see [Fig. 5.3](#)). Determining the cut line and the direction of view as well as the detail to be included is important. The term section refers to a simple profile but is often taken to mean a full-height sectional elevation. It is essential that the terms are used correctly.

5.3 Control for measured building surveys

5.3.1 Control of survey data

The control of measured building surveys is to be achieved principally by use of an adjusted traverse network and must meet the performance described in [Section 2.2](#). However, it will also be acceptable to derive survey drawings from a laser scan point cloud controlled as specified in [Section 3](#).

5.3.2 Heights on floor plans

Where plans for more than one floor level are required, the heights shown for each floor must be given relative to a single datum. Multiple arbitrary datum points for each floor must not be used.

5.3.3 Accuracy of survey data

The plan position of any well-defined detail will be accurate to $\pm 0.3\text{mm}$ rmse at the specified plan scale when checked from the nearest survey control station.

To verify the achievement of the specified tolerances, the following may be required:

- booked data showing directly measured dimensions
- coordinate data and their provenance, where dimensions between points have not been directly measured.

5.3.4 Precision of detail measurement

The precision of detail measurement is to be as specified in Section [2.1.2](#).

5.4 Drawing content

5.4.1 Detail required

The required scale of survey will determine both the level of detail and the expected precision. The level of detail refers to the density of information, while precision refers to the performance of the measured points used to delineate the detail. At a larger scale, such as 1:20, a plan, section or elevation will show more information than at a smaller scale, for example 1:50 or 1:100.

Detail comprises the visible features delineated within a plan, sectional elevation or elevation, such as openings, straight joints, roof scars, the jointing of masonry, the outline of fittings and fixtures, or the outline of materials used. Sectional detail is to include eaves, sills, lintels, sashes, etc.

1:100 and 1:50 scale

The smallest plottable detail is 0.2mm (at 1:50 scale this equates to a 10mm by 10mm object), so a degree of generalisation is required.

- Large linear objects, such as skirting or cornices, must be shown as a light line inside the wall or cut line.
- Annotation indicating floor material and direction of floorboards is to be included. A single line can be used to show joints in timber or for floor coverings.

- Openings in plan may be generalised but must show an indication of the type of detail by careful use of an approved symbol for sash, mullion, door swing and lining.
- For elevations at 1:100, repetition of a single measured window is permitted in cases where they are demonstrably similar.
- Overhead detail, such as beams, vaults, stair flights, reveals, etc., must be shown as a dashed line.

1:20 scale

All detail and annotations that would appear at 1:50 will also be present at 1:20. In addition, all visible architectural features must be shown, including:

- mouldings and sculptural detail from actual-size source material (such as a profile trace or measured drawing)
- all stone-by-stone detail and galleting for elevations
- floor detail, such as the plan of stone flags or floor tiles for plans
- timber components, with pegs, peg holes and open or re-used joints plotted using a separate line to describe each component
- eroded edges as seen in the required view, to show the condition of the fabric
- the deformation of wall surfaces at the cut line and foot of wall line
- openings in full detail as apparent from the plane of reference

or as specified in the project brief.

5.5 Drawing convention

5.5.1 Curved features

Curved features will be presented:

- (a) either unwrapped
- (b) or as an orthogonal view

as stated in the project brief. The method proposed for any required unwrapping of data must be outlined in the method statement.

Further information

When requesting that a curved surface be unwrapped beware that, unless the subject is a true cylinder, there are likely to be scale distortions in the end result. This is especially the case where there are changes in depth, such as window reveals.

5.5.2 Depiction of cut line (plan and section)

The cut line(s) must be shown with a line weight of a thickness determined by the output or plot scale.

Sections and sectional elevations

The cut lines of any sections or sectional elevations will be clearly shown on:

- (a) either the accompanying plan
- (b) or a key plan

as stated in the project brief. The line must include arrows showing the direction(s) of view (Fig. 5.4).

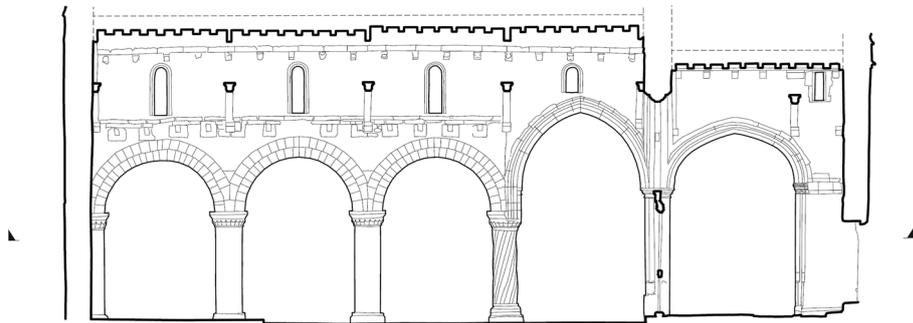
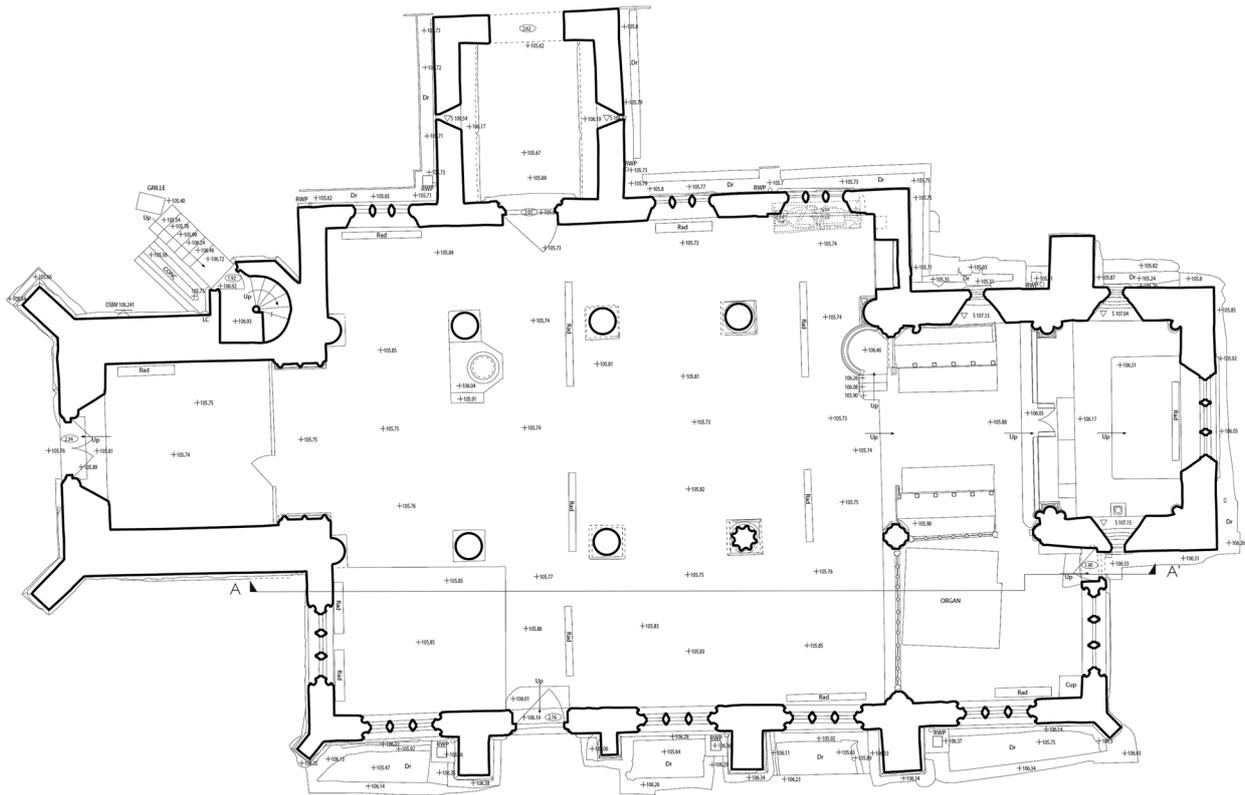
Building footprint

The contact lines between the building and the ground (also known as the ground line, when visible in elevation) must be shown with a lighter line than the cut line. The visibility of the line will depend on the wall, its inclination and the required scale.

The building footprint is to be:

- (a) shown
- (b) or omitted
- (c) or recorded in 3-D in a frozen layer

as stated in the project brief.



Section A - A'

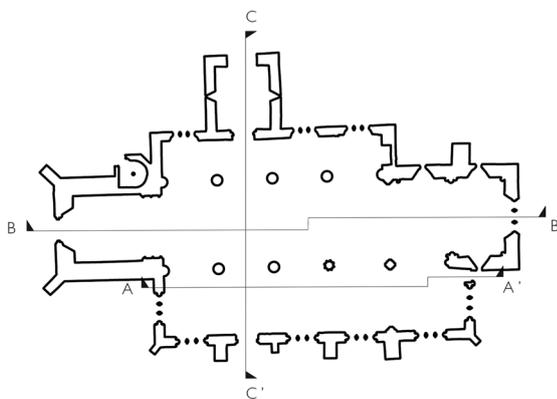


Figure 5.4: (top) Section lines; (middle) shown related to plan; (bottom) multiple sections depicted on a key plan.

Further information

The building footprint or ground or floor line is the line at the foot of the wall. Plans of vertical walls that have a constant width over their full height will not show this line unless it is specifically requested. Where a wall has a batter or sits on a plinth, the line will be visible and should appear on the plan. If a wall tilts the ground line may appear within the cut line in which case it should be shown dotted.

5.5.3 Use of symbols

Symbols may be used as tabulated below. Level and dimension values are to be shown to 2 decimal places throughout:

Item	Scale	Size on plot	Symbol
Door swing	1:20	Full extent of swing	Shown as an arc
Door swing	1:50	Open at 90° or 45°	Shown as an arc
Levels	1:20 and 1:50	2mm cross, text 2mm plot height	Cross with value to top right
Step direction	1:20 and 1:50	Text 2mm plot height	Arrow pointing up direction of run, labelled 'UP'
Glazing detail	1:20 and 1:50	Text 2mm plot height	Single line on centre of window frame; frame beads omitted
Room height	1:20 and 1:50	Text 2mm plot height	Enclosed in an ellipse
Window/door opening height	1:20 and 1:50	Text 2mm plot height	Small upward and downward pointing open arrow heads
Window/door soffit/lintel height	1:20 and 1:50	Text 2mm plot height	Small upward pointing open arrow head
Window/door sill/threshold height	1:20 and 1:50	Text 2mm plot height	Small downward pointing open arrow head
Roof survey: direction of fall	1:20 and 1:50	Length of arrow varies	Arrow pointing down slope
Windows and doors	1:100	Repetition of a single measured type permitted	Repetition of a single measured type permitted

5.5.4 Point density and line quality

Point density and line quality are to be in accordance with the performance specified in Section 2.1.

5.5.5 Use of 'best profile'

The depiction of architectural forms requires special attention to the detail of functional openings such as sills, door openings, splays, mullions, plinths, etc. Mouldings must be shown as completely as possible, with the 'best profile' shown. Where a profile of a damaged or eroded moulding can be derived with certainty it will be shown 'as complete' with the cut line profile shown as a dashed line.

5.5.6 Assumed detail

Assumed detail will be presented using dashed lines, clearly indicated and on a separate layer. If detail is absent from a drawing, then the space is to be annotated with an explanation (e.g. 'no access', 'obscured at time of survey').

5.5.7 Use of text

Text is only to be used if the information needed cannot be displayed as a graphic component of the drawing. Use of text is restricted to:

- annotation of direction of steps
- description of material and services using appropriate abbreviations
- values of spot heights, room heights, etc.
- notification of restrictions to survey (see Section 5.5.6)
- as required by Section 7.

The text height is to be 2mm at the plot size.

The text font is to be:

- (a) either Arial
- (b) or as stated in the project brief.

The text is to be positioned on the drawing such that it is:

- aligned with the sheet edge if possible
- aligned with large linear objects
- as close as possible to the object described
- not overlapping or breaking plotted lines
- preferably to the upper right of the object described.

If the upper right default position causes text to be in conflict with detail or other text, it is to be placed elsewhere in the following order of preference:

- upper left
- lower left
- lower right
- rotated at default position to avoid clash.

5.5.8 Overhead detail on plans

Large-scale surveys will require depiction of the principal features of overhead structures such as vaults, beams, gantries, ceiling details, high-level windows, roof lights, pulleys, murder holes, etc (Fig. 5.5). The annotation 'at high level' or '(at HL)' can be used to indicate detail above the plan height if it is not clear from the plotted lines alone.

Vaults, at 1:50 and 1:20 scale, will be shown by a plot of the rib lines, with imposts and bosses in outline. A single dashed line indicating the centre line of the rib may be used at 1:100 scale.

Overhead detail is to be:

- (a) either recorded in 3-D and plotted at true height
- (b) or plotted in two-dimensions (2-D) congruent with all other plan detail

as stated in the project brief.

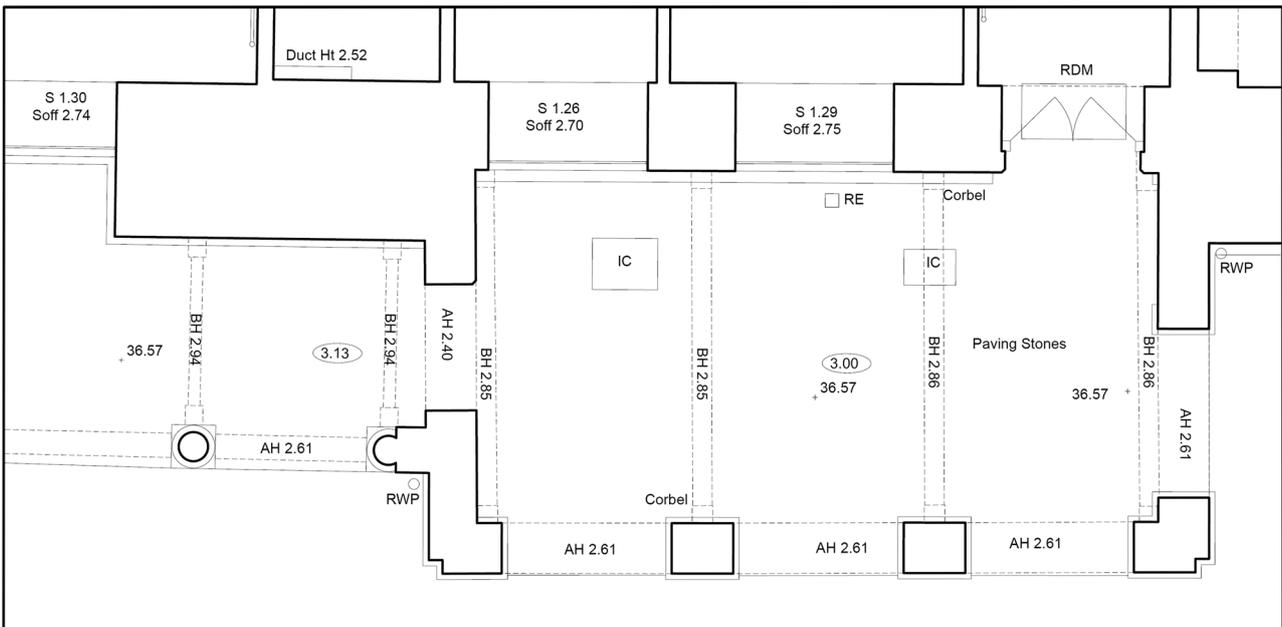
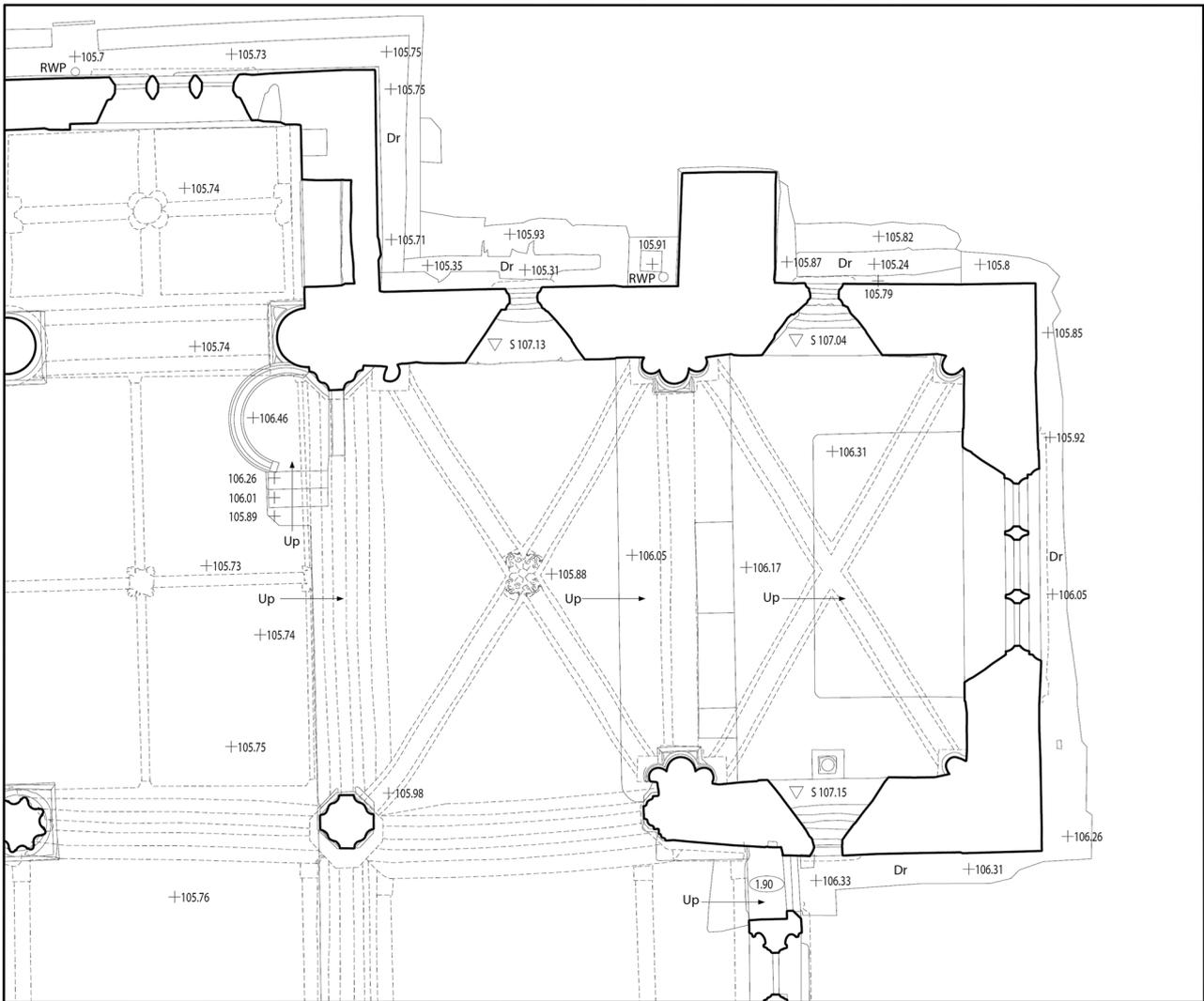


Figure 5.5: Examples of overhead detail; **(top)** plan with a vaulted ceiling – 1:20 level of detail; **(bottom)** overhead beams on a plan – 1:50 level of detail.

5.5.9 Floor detail on plans

Plans at 1:20 and 1:50 scale are required to show the following floor details:

- changes in floor treatment
- changes in floor level
- steps, with the line of tread noses (continuous) and for 1:20 risers (dashed, if undercut)
- flagstones, etc., depending on scale.

Fixings to walls and floor as seen on the cut line (hinges, sockets, niches, etc.) will be shown in a line thickness greater than that used to depict all other detail.

5.5.10 Treatment of staircases on plans

The required convention for the depiction of stairs is to show the plan as seen from the cut line and to use a break line to show the interruption of the plan (Fig. 5.6). Where stairs include detail such as half landings between floors that would not otherwise appear on a drawing, an inset plan is to be used. Overhead detail is to be shown as required by Section 5.5.8.

Levels on steps and stairs will be shown:

- (a) either on each landing
(i.e. at the top and bottom of each flight)
- (b) or on all treads.

Stairs are:

- (a) to be annotated with numbers to each tread
- (b) and/or annotated with an 'up' arrow as described in Section 5.5.3
- (c) or not to be annotated

depending on the project brief.

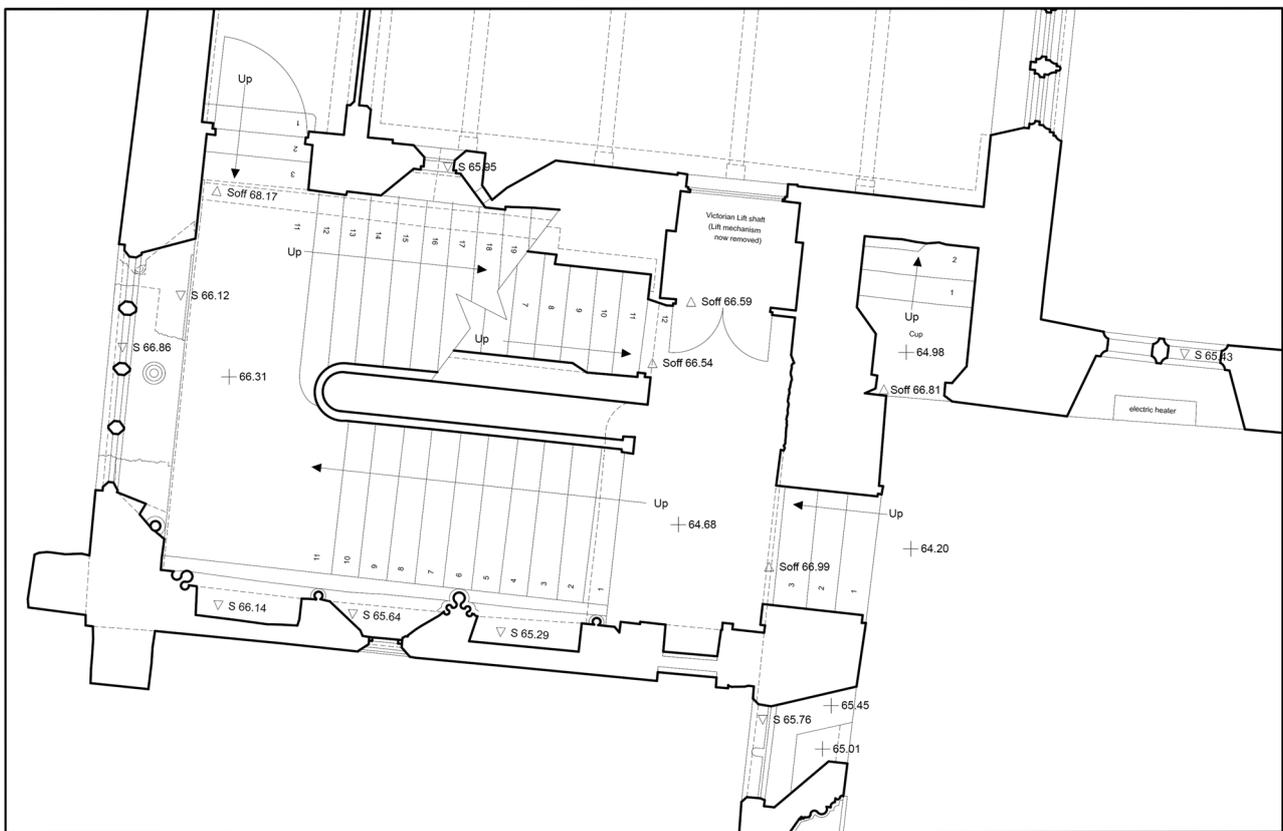
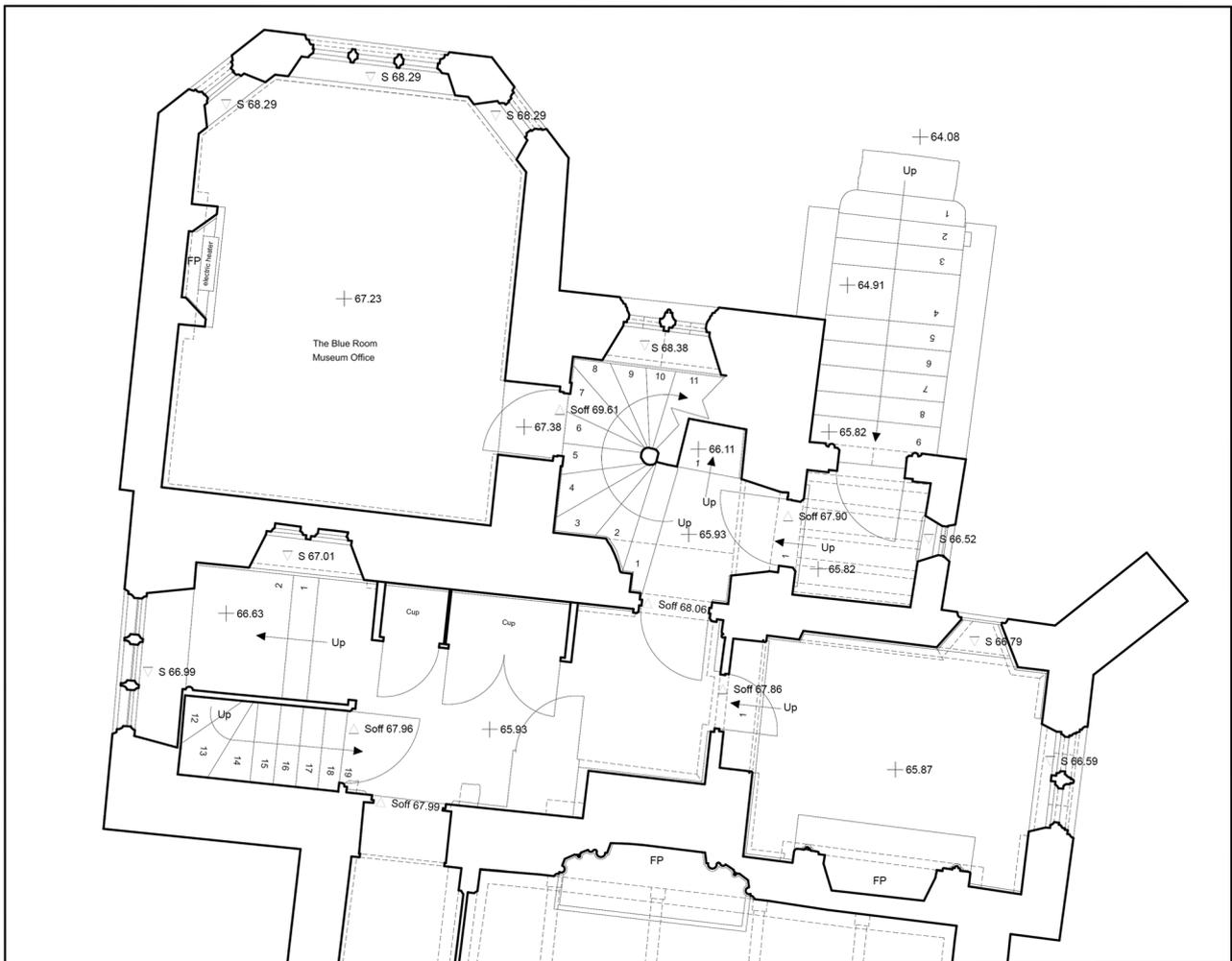


Figure 5.6: Two examples of the treatment of staircases on plans.

5.5.11 Services

Large components such as radiators, exposed pipework, shafts, ducts, etc., must be shown in full detail. Smaller components may be indicated by standard symbols and/or annotation. The following service details must be shown and annotated with service type:

- large fittings only
- pipework
- rainwater goods
- duct work
- electrical fittings (in elevations only).

Electrical wiring and fittings are not usually required to be shown on plans unless specified in the project brief.

5.5.12 Levels

Levels must be shown relative to the vertical datum as specified in Section 2.

Levels must be located at the following locations where applicable:

- thresholds
- either side of door openings
- centre of each room
- each corner of each room
- interior sills
- exterior sills on the centre of sill boards
- lintel soffit.

The heights of window and door openings will be:

- (a) either as indicated by soffit/lintel and sill heights
- (b) or shown as an opening height

as stated in the project brief.

Floor to ceiling heights are required for each room and are to be shown enclosed in an ellipse.

5.5.13 Roof survey

Roof survey drawings can be presented in one of two states:

- (b) either with the roof cover off ([Fig. 5.7 top](#)).
- (a) or with the roof cover (slates, tiles, lead, etc.) on ([Fig. 5.7 bottom](#))

A survey may be required to show rafters and trusses or trusses only.

A roof plan is required showing:

- (a) 'cover on'
- (b) or 'cover off'
- (c) or 'cover off trusses only'

as stated in the project brief.

In all cases the roof must be shown in plan, i.e. looking straight down.

Appendix 5.1 CAD layer names for measured building survey

See the tables for the standard layer names used for measured building surveys and some additional layers for vault surveys.

Note that:

- This is not an exhaustive list.
- New layers may be created as long as they are prefixed with 0A-.
- The cut line of a building or feature will be of a heavier weight than lines used for other detail.
- The line type will be controlled so that dashes are 0.5mm long with a 0.5mm gap at the plot scale.
- A dot and peck line type will be used to indicate any or all of the line types in the table if there is a conflict of lines. The dot and peck line will comprise a line 1mm in length separated by a 0.5mm gap from a dot of 0.18mm, with a 0.18mm line width.
- A dotted line may be used for clarity if there is a large number of dashed lines on the drawing sheet. The dotted line will be a 0.18mm or 0.25mm diameter dot at a 2mm to 5mm interval, depending on the plot scale.
- In AutoCAD, LTGEN is to be set to on.

Layer	Line type	Line weight (mm)	Line weight (mm)	Line weight (mm)	Description
		1:20	1:50	1:100 and over	
0A-chimney	Continuous	0.35	0.25	0.25	
0A-cut_line	Continuous	0.5	0.35	0.35	The cut line or section line
0A-detail	Continuous	0.18	0.18	0.13	Below plan detail, outside cut line
0A-detail_hidden	Dotted	0.13	0.13	0.13	Below plan detail, inside cut line
0A-fine_detail	Continuous	0.09	0.13	0.13	Below plan fine detail, outside cut line or within detail on elevations
0A-detail_project	Dashed	0.18	0.18	0.13	Projected: in front of section line
0A-grid	Continuous	0.18	0.18	0.18	Grid points to be frozen on presentation
0A-grid_text	Continuous	0.18	0.18	0.18	All text associated with the grid: annotation to be aligned with the grid line
0A-inst_cntl	Continuous	0.13	0.13	0.13	Control positions: to be frozen on presentation
0A-joist	Continuous	0.13	0.13	0.13	
0A-level	Continuous	0.13	0.13	0.13	
0A-level_text	Continuous	0.13	0.13	0.13	
0A-trav	Continuous	0.13	0.13	0.13	Control diagrams: to be frozen on presentation
0A-overhead	Dashed	0.13	0.13	0.13	Overhead detail: 2mm line, 1mm spacing
0A-opening	Continuous	0.25	0.25	0.18	Lines describing the edges of openings, changes of plane or skyline
0A-plinth	Continuous	0.13	0.13	0.13	Plinth lines in plan, inside building
	Continuous	0.25	0.18	0.13	Plinth lines in plan, outside building
0A-purlin	Continuous	0.13	0.13	0.13	
0A-rafter	Continuous	0.13	0.13	0.13	

Layer	Line type	Line weight (mm)	Line weight (mm)	Line weight (mm)	Description
		1:20	1:50	1:100 and over	
0A-svs_elec	Continuous	0.13	0.13	0.13	
0A-svs_fire	Continuous	0.13	0.13	0.13	
0A-svs_foul	Continuous	0.13	0.13	0.13	
0A-svs_gas	Continuous	0.13	0.13	0.13	
0A-svs_other	Continuous	0.13	0.13	0.13	
0A-svs_water	Continuous	0.13	0.13	0.13	
0A-text	Continuous	0.13	0.13	0.13	
0A-title	Continuous	0.35	0.35	0.35	
0A-truss	Continuous	0.25	0.25	0.25	
0A-wallplate	Continuous	0.13	0.13	0.13	

Additional layers for vault surveys:

Layer	Line type	Line weight (mm)	Line weight (mm)	Line weight (mm)	Description
		1:20	1:50	1:100 and over	
0A-boss	Dashed	0.13	0.13	0.13	Bosses may be shown as an outline
0A-cap	Dashed	0.13	0.13	0.13	Capital, impost or abacus
0A-corbel	Dashed	0.25	0.25	0.25	On plans, if at high level, shown as an outline
0A-rib	Dash in plan Continuous for elevations	0.13	0.13	0.13	For the rib lines; to be expanded according to rib type if required
0A-shaft	Dashed	0.5	0.35	0.35	On plans, usually shown as a cut line; on sections, use detail line weight

6

Standard specification for topographic survey

6.1 Topographic survey

6.1.1 Definition of topographic survey

For the purposes of this document topographic survey is defined as the controlled measurement of natural and artificial landscape features. It is to be presented as:

- (a) either a 2-D
- (b) or a 3-D

dataset reading as a plan, as stated in the project brief. Profiles and a DTM may also be required (see Section 6.6).

6.2 Description of products

For the purpose of producing large-scale topographic survey, the following definitions apply.

6.2.1 Plan

This will be:

- (a) either a vertical orthographic projection onto a horizontal reference plane
- (b) or a cartographic projection and a scale factor may be applied

as stated in the project brief.

The plan may incorporate information above and below the reference plane; buildings shown will normally be cut on a different horizontal plane to that used for the main plan. The view is to be presented both as plotted or drawn 'hard copy' such that there is no discrepancy beyond permitted standard error (see Section 2) and as a CAD file containing the same data as the plot.

6.2.2 Profile

An orthographic projection onto a vertical reference plane. Profiles will show the surface or cross-section of the ground, including the thickness of any walls. The end-points and line taken by the profile(s) will be clearly marked on a key plan. The vertical exaggeration for such views will be $\times 1$ unless otherwise stated.

6.2.3 Detail

The visible features, excluding the surface of the terrain, shown on the plan. It may be considered either 'hard' or 'soft'.

Hard detail is that defined with a clearly visible edge, for example a kerb.

Soft detail has an undefined edge or surface, for example earthworks.

6.3 Survey control

6.3.1 Coordinate system

Where use of the Ordnance Survey National Grid is specified, the primary site control, or starting coordinates for it, is to be established by means of GNSS observation as specified in Section 2. The scale factor used must be reported in the survey documentation.

The method statement must describe the equipment and procedures to be employed, to achieve the precision specified in Section 2.1.2.

Secondary control may be achieved by traverse observations.

6.3.2 Adequate site cover

The control network or traverse must extend so that stations are in reasonable proximity to the perimeter of the survey area and the detail to be mapped.

The distribution of stations is to be:

- (a) either at the discretion of the surveyor
- (b) or decided in consultation with the client

as stated in the project brief.

6.3.3 Precision of detail measurement

The precision of detail measurement is to be as specified in Section 2.1.2.

6.4 Detail required

6.4.1 Scale

Topographic survey is required at a scale as specified in the project brief.

If the survey is to be presented at more than one scale, different sizes of text are to be layered in the CAD file so that they may be segregated to allow for legibility at both scales.

It may be necessary to carry out some of the survey at a larger scale than that commensurate with the plot scale. Reference will be made in the project brief regarding the area and nature of 'over scale' survey required. At 1:500 scale, a degree of generalisation from the 1:200 level is acceptable. The smallest plottable detail is 0.2mm by 0.2mm, which equates to 100mm by 100mm at 1:500 scale, therefore symbols will be used to describe visible features smaller than this.

For all hard detail the accuracy of planimetric information will be such that the plan position of any point will be correct to within ± 20 mm rmse when checked from the nearest permanent control station, when surveyed for presentation at scales between 1:100 and 1:200. At 1:500 scale, any point of hard detail will be correct to within ± 30 mm rmse.

6.4.2 Detail required

The following general categories of information will be surveyed:

- roofed buildings/structures (Fig. 6.1)
- roofless/ruined structures
- temporary/mobile buildings
- visible boundary features, e.g. walls, fences and hedges
- roads, trackways, footways and paths
- street furniture
- statutory authorities' plant and service covers, where visible
- changes of surface
- isolated trees/wooded areas/limits of vegetation (Fig. 6.2 and Fig. 6.3)
- pitches/recreation areas
- private gardens or grounds
- water features
- earthworks
- industrial features
- railway features (with arranged access)
- aboveground services
- underground services (see Fig. 6.4)
- other (specify).

All of the above are to be presented using the specified cartographic conventions (see Section 6.6), and either drawn or depicted using symbols dependant on output scale. The plans will have a fixed control network and measurable repeatability of precision commensurate with the required scale (see Section 2.1.2).

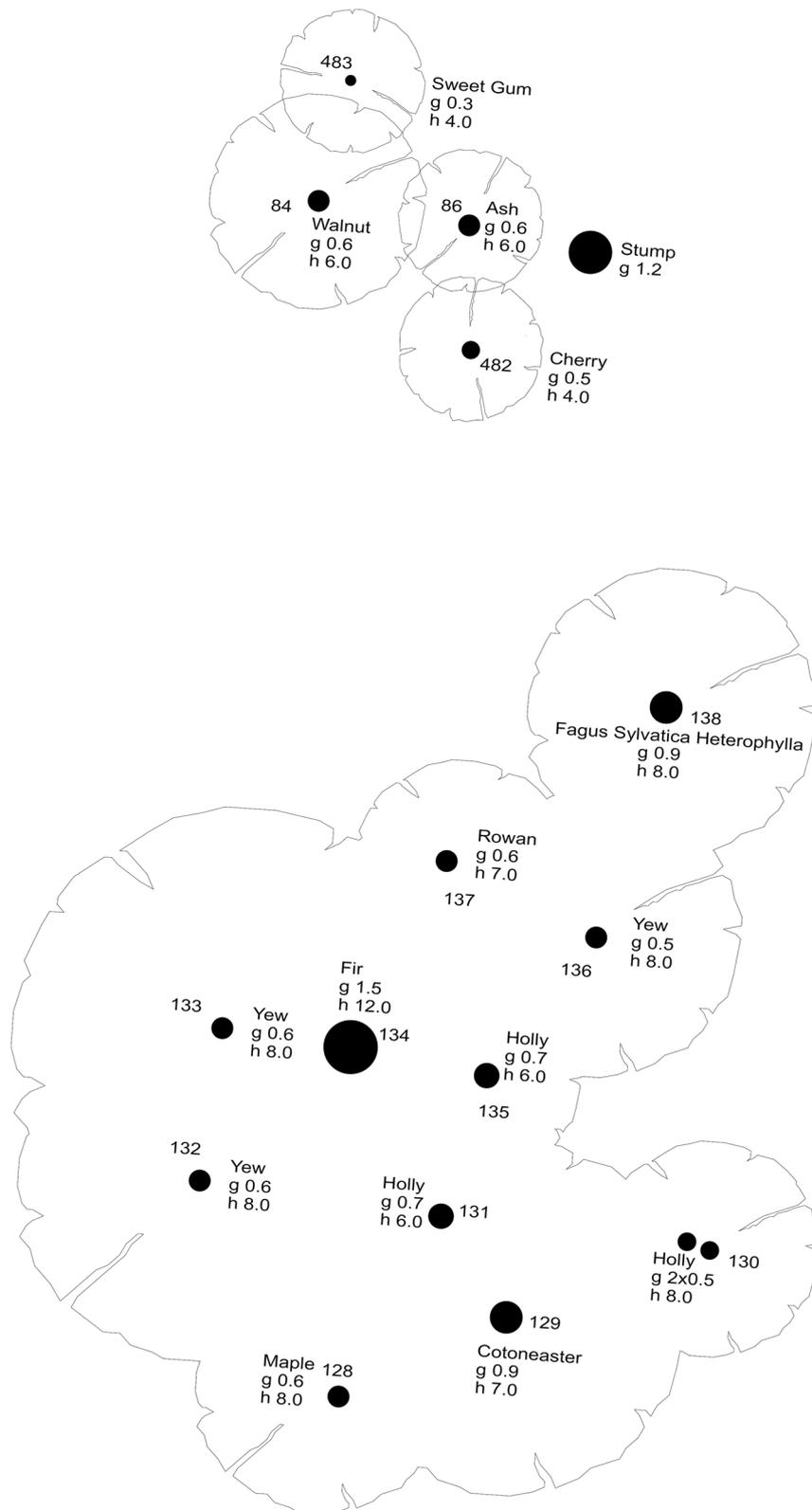


Figure 6.2: Depiction of trees; (top), canopies untrimmed; (bottom) canopies trimmed to the overall envelope.

6.4.3 Obstructed ground

Details or contours that cannot be represented to the specified accuracy without extensive clearing will be:

- (a) surveyed approximately and annotated accordingly
- (b) or surveyed following clearance by the client
- (c) or surveyed following clearance by the survey contractor

as stated in the project brief.

6.5 Underground services

An accurate base plan is essential for the plotting of underground utility services. If such a plan does not exist it will be necessary to produce one (Fig. 6.4).

Underground services surveys will be undertaken using one or more of the following methods.

- (A) Consulting underground service records. (To be taken from statutory or other authorities' record drawings and plotted to agree as closely as possible with surveyed surface features.)
- (B) Direct visual inspection. (Accessible inspection chamber covers should be lifted where permissible and services positively identified.)
- (C) Direct visual inspection supplemented by consulting service record drawings. (Accessible inspection chamber covers should be lifted where permissible and services positively identified. Routes of services between access points to be taken from record drawings and plotted to agree as closely as possible with surveyed surface features and trench scars where obvious.)
- (D) Full investigation, including electronic tracing. (Services to be fully investigated by visual survey supplemented by electronic or other tracing of inaccessible routes.)

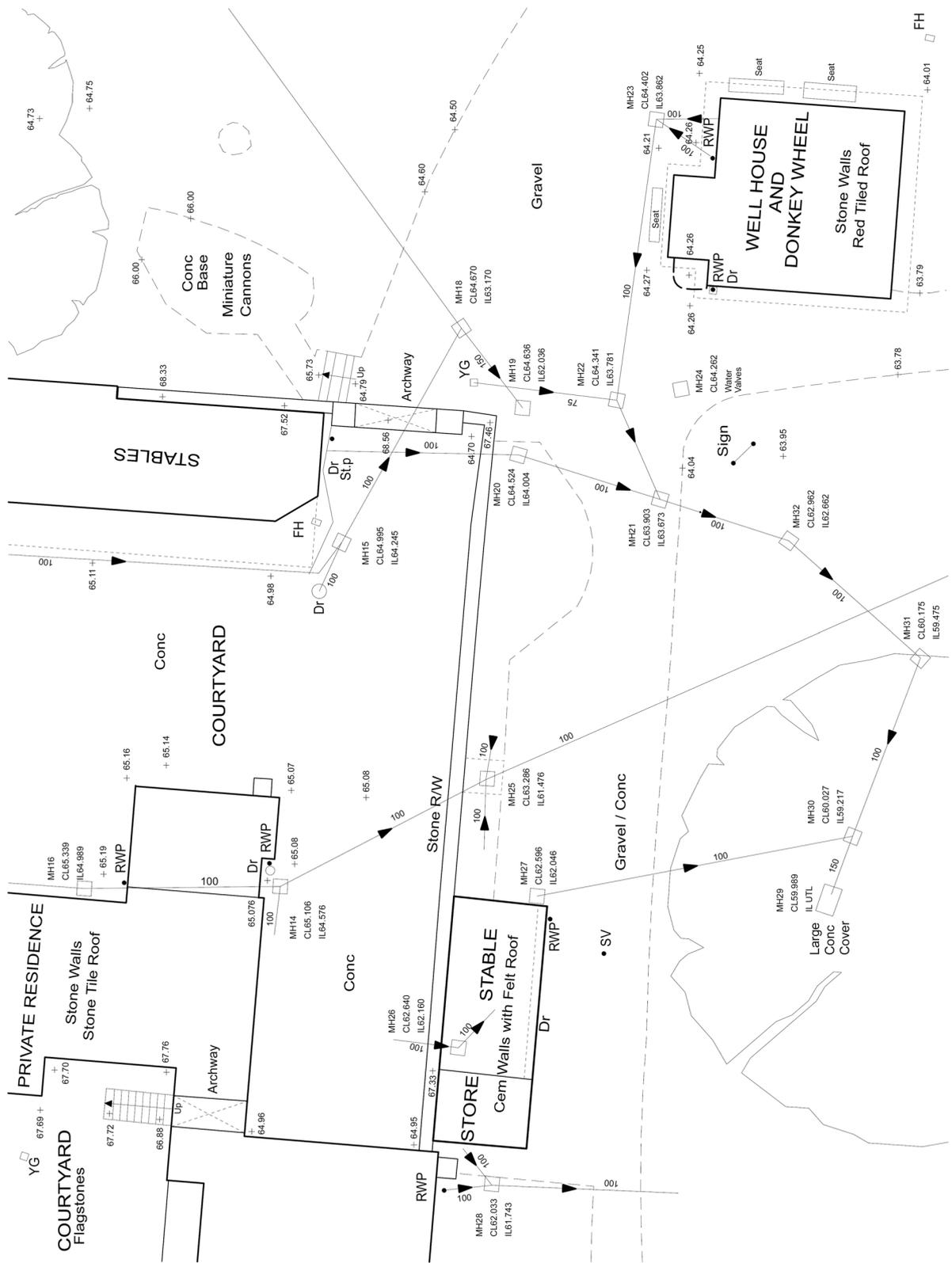


Figure 6.4: Depiction of underground services. Originally prepared for presentation at 1:200 scale.

Further information

(A) Record information

Existing information taken from record plans covering underground services is often incomplete and of doubtful accuracy. It should usually be regarded only as an indication and cannot be guaranteed.

(B, C) Underground services surveys

Drainage covers should not be lifted without the permission of the owning authority. Many local authorities do not permit their inspection covers to be lifted but will provide some information for a standard fee.

(D) Electronic tracing

This is a more reliable method of locating buried services. On heavily built-up sites, 85% completeness is probably all that can be expected. Plan accuracies of $\pm 150\text{mm}$ may be achieved but this will be dependent on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited. Further guidance, if required, on utility surveys can be obtained free of charge from [TSA](#).

For a comprehensive specification, see the 2022 British Standards Institution (BSI) fast-track standard PAS 128:2022 *Underground Utility Detection, Verification and Location. Specification*.

6.5.1 Extent of survey required

The services listed below will be surveyed by one or more of the methods listed above as indicated in the project brief:

- surface water drainage
- foul drainage
- water
- gas
- electricity
- telecommunications
- other services
- other underground features.

All work will be carried out with due regard to the health and safety regulations for working within confined spaces (see Section 1.4.4).

6.5.2 Services information

Information derived from survey methods (B), (C) and (D) (see Section 6.5) will be supplied as:

- (a) either invert levels, pipe diameters and annotations on drawings or digital files
- (b) or inspection chamber description sheets

as stated in the project brief.

The date of inspection/survey must be included.

6.5.3 Derived information

Where information is derived from statutory authorities' record drawings, a schedule will be provided giving full details (e.g. drawing number, scale, date). All information taken from records will be clearly identified as such in the survey product and placed on a separate layer.

6.5.4 Report

A report will be submitted indicating any anomalies between surveyed data and records, detailing likely accuracies achieved and commenting on services not located for any reason (e.g. unliftable or hidden covers). All identified features will be highlighted in this report.

6.6 Drawing convention

6.6.1 Landform, earthworks and surface terrain

Landform, earthworks and surface terrain are to be indicated by:

- surveyed contour
- form line
- annotation
- spot height
- hachure.

6.6.2 Contouring and DTMs

Contours are required to represent the surface characteristics of the terrain. They are to be shown with contour values reading up the slope at a density sufficient to identify all contours without ambiguity. Where contour values are annotated, the contour lines must be broken to ensure legibility. The contours must be shown cut by buildings and structures, including the batter of masonry fortifications built into earthworks. Contour lines must be appropriately smoothed after interpolation to avoid lines with sharp changes in direction.

Contours derived from a DTM must not reveal the geometric model used to construct the surface. Care must be taken to ensure that the presence of detectable edges is only a result of such edges being part of the landscape. Break lines will be used to ensure that the DTM accurately describes the landform to be depicted by identifying changes of slope at, for example, the tops and bottoms of ditches and banks (Fig. 6.5). When earthworks are mapped, attention must be paid to the surface and its intersection with objects such as gun emplacements, battered walls, chimneys, etc., so that a plan of the building components can be seen clear of the contours used to describe the earthworks or landform surrounding them. For the required accuracy of contours, see Section 6.6.3.

Plans at 1:100 and 1:200 scale are to be contoured at a vertical interval of:

- (a) either 0.5m
- (b) or as stated in the project brief.

Plans at 1:500 scale are to be contoured at a vertical interval of:

- (a) either 1m
- (b) or as stated in the project brief.

Thicker index contours are to be shown at:

- (a) either multiples of 1m
- (b) or as stated in the project brief.

Hachures may be used to supplement contoured information and to describe sub-contour detail (Fig. 6.6).

Sufficient levels for the DTM will be surveyed such that the ground configuration, including all discontinuities, is represented on the survey plan.

The maximum spacings for DTM points are:

Scale	Ground spacing	Distance on plan
1:100	5m	50mm
1:200	10m	50mm
1:500	10m	20mm

Where a DTM is the final product, the density of levels will be such that the surface of the model is constructed within 0.1m of the true surface when verified by check measurement. The density of levels will be at least 1m for surfaces with earthworks or 5m for open ground.

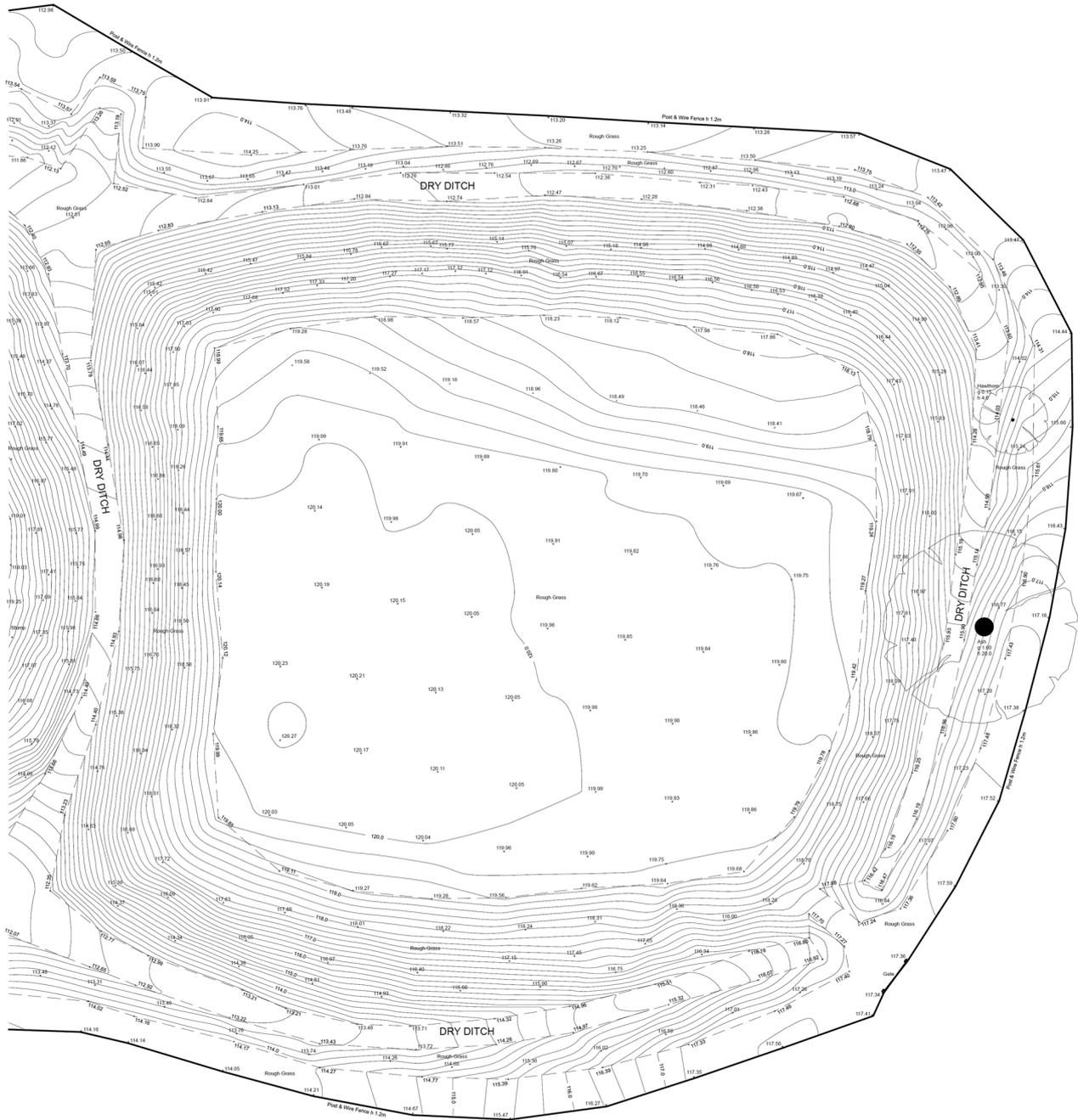


Figure 6.5: Contours generated from a DTM and breaklines. Originally prepared for presentation at 1:200 scale.



Figure 6.6: Use of hachures to supplement information from contours. Originally prepared for presentation at 1:200 scale.

6.6.3 Location of spot heights

Spot heights will be shown in the following positions, except where the ground is obscured by vegetation or other obstructions:

- at salient positions such as top, bottom and along the centre line and mid-point of slopes, ditches, embankments and earthworks
- at the top and bottom of features described by hachure to support the form lines
- at significant changes of gradient, along the centre and edges of road, tracks and water courses, at between 50mm and 100mm at map scale
- in flat areas (where the horizontal distance between contours generally exceeds 30mm at map scale) at intervals between 30mm and 100mm at map scale
- at the sill tops and thresholds of buildings, ruins and building fragments
- at the base of walls, showing height of ground at the corners, buttresses and change of direction of walls (to include corresponding positions either side of a freestanding wall)
- wall tops on ruined walls, to indicate major changes in wall height and maximum height (large and irregular ruined walls may not require levels other than a general indication of height)
- at regular intervals along dwarf walls, showing the height of ground at the wall base and wall top
- at changes of surface treatment (e.g. the edges of grassed areas and hard standing, paths, walkways)
- at the surface of drainage inspection covers, the invert level of drainage pipes, on the edge of rainwater gullies and along rainwater channels
- at the edges and high points of large fragments of buildings (fragments of 1m by 1m size or greater on any edge at actual size)
- at the top and bottom (and if practicable on each tread) of flights of steps
- at the base of the bole of large trees.

The required control and precision of vertical data is described in Sections 2 and 6.3.

The standard point descriptor must be a cross of no more than 2mm by 2mm at plot size, the intersection of which will represent the given coordinate value. The symbol is to be aligned with the sheet edge. The point descriptor will be used for the depiction, with appropriate annotation, of spot heights and reference points. Spot height text will be 2mm high at plot scale and given to 2 decimal places.

6.6.4 Depiction of trees and vegetation

Vegetation is to be indicated by a standard scaled symbol and text description of species by common name.

Trees are to be plotted as up to four components: the base, bole, canopy/spread and envelope. Trees are considered to be identifiable as such if they are 5m or greater in height, unless of a species known as a shrub (such as laurel) and lacking an identifiable bole.

If less than 5m, high trees will be depicted as vegetation. Trees, including the bole, are to be shown to scale. Any displacement of the tree canopy from the bole will be shown. Single small trees in unobstructed terrain will be shown even if they may not be of a size that normally qualifies for depiction. Small trees of less than 5m in height are to be layered in the CAD file separately to aid landscape management.

General points

The bole is to be plotted at 1.5m above ground level and to include multiple grouped boles. They are to be a scaled and hatched shape that appears solid on the plotted drawing sheet. The hatching used must be consistent for all bole sizes.

The spread of the canopy is to be shown as a standard scaled symbol. At 1:200 scale and greater, the canopies are to be contained within the digital file such that both the individual spread per tree is shown in one CAD layer and the envelope of a group of trees is shown in another (see Appendix 6.1 and Fig. 6.2). At 1:500 scale, depiction of the envelope only is sufficient. Where a small tree has an extensive canopy spread over other vegetation, the canopy will be mapped as a dashed line.

Trees are to be annotated with the following information:

- the tree number, where visible
- species by common name
- height to the nearest 0.5m.

For vegetation, hedges are to be depicted using a linear symbol. They will be surveyed so that the centre line, width and descriptive annotation are clearly shown on the plan (see [Fig. 6.3](#)).

The extent and type of other vegetation is to be shown, annotated in a similar manner to that used for hedges.

6.6.5 Text style and positioning

For annotation, levels, index contours and descriptions of form or surface treatment, the height of text will not exceed 2mm at plot scale. For major objects the text will be 5mm in height at plot scale.

The font used is to be:

- (a) either Arial
- (b) or as stated in the project brief.

Text is to be positioned on the drawing such that it is:

- aligned with the sheet edge if possible
- aligned with large linear objects
- as close as possible to the object described
- not overlapping or breaking plotted lines
- preferably to the upper right of the object described.

If the upper right default position causes text to be in conflict with detail or other text, it is to be placed elsewhere in the following order of preference:

- upper left
- lower left
- lower right
- rotated at default position to avoid clash.

6.6.6 Treatment of steps

Where space on the drawing allows, an arrow pointing up a flight of steps will be used to support level information. The symbol will extend the full length of the flight and must be labelled 'up'.

6.6.7 Depiction of buildings and walls

For roofed structures, the cut line is to be:

- (a) either at ground level
- (b) or at sill height

as stated in the project brief, and will show returns for doors and windows on the outside only.

Roofless or ruined structures must have their internal layout (such as walls or columns) shown.

Spot levels must be shown on sills, thresholds and floors.

Annotations indicating floor, wall and roof material as well as building height are to be included.

On plans at scales of 1:100 or larger, floor detail will be required if visible.

Free-standing walls must be shown at a nominal plan height, with lines closed to show openings, where possible.

Additional detail below the plan height (sills, thresholds and floor treatments, etc.) will be:

- (a) either shown
- (b) or not required

as stated in the project brief.

At 1:200 scale, detail such as plinths may be omitted if the projection from the wall line is less than 2mm at plot scale.

Where a wall is leaning over significantly from the line of its base, it will be necessary to show the true plan position of both the top (or nominal plan height) and bottom of the wall.

6.6.8 Above ground utilities and boundaries

Services, roads, tracks, water courses, fences, boundaries, etc., are to be delineated by use of:

- (a) surveyed lines
- (b) and/or symbols
- (c) and/or text.

Fence lines are to be indicated by the plotted plan position of posts; the position and width of gates are to be to scale. At 1:500 scale or smaller, building openings, gates and the position of fence posts in plan may be generalised, i.e. depicted by a symbol or line type.

Ditches are to be shown by a dashed line showing the top of the bank. The bottom of a bank is to be supported by a spot level at changes of height for each surveyed line.

Overhead services such as telephone or electricity cables are to be shown with a distinctive line type and annotated with the service description and height above Ordnance Survey datum.

Appendix 6.1 CAD layer names for topographic survey

See the tables for the standard layer names used for topographic surveys.

Note that:

- This is not an exhaustive list.
- New layers may be created so long as they are prefixed with 0T-.
- The cut line of a building or feature will be of a heavier weight than lines used for other detail.
- The line type will be controlled so that dashes are 0.5mm long with a 0.5mm gap at the plot scale. The exception is for lines showing changes in surface treatment, where the dashes will be 2mm with a 1mm gap.
- A dot and peck line type will be used to indicate any or all of the line types in the table if there is a conflict of lines, and for boundaries if required to avoid confusion. The dot and peck line will comprise a line 1mm in length separated by a 0.5mm gap from a dot of 0.18mm, with a 0.18mm line width.
- A dotted line may be used for clarity if there is a large number of dashed lines on the drawing sheet. The dotted line will be a 0.18mm or 0.25mm diameter dot at a 2mm to 5mm interval, depending on the map scale plotted.
- In AutoCAD, LTGEN is to be set to on.

Layer	Colour (Numbers in parentheses are AutoCAD colours)	Line type	Line weight (mm) Up to 1:200	Line weight (mm) 1:500 and over	Description of content
0T-breakline	Black	Dashed	0.18	0.13	In support of contour or hachure, to describe, e.g., top and bottom of slope
0T-cntl_text	Black	Continuous	0.25	0.18	Schedule of coordinates for control stations; to be shown to 3 decimal places with a description of the marker used; may be included on data sheet for project or as separate file
0T-contour	Green	Continuous	0.18	0.13	Minor contours
0T-contour_index	Red	Continuous	0.25	0.25	Index contours; to be broken to accept contour value; text to be positioned so that the top of the text faces up slope
0T-cut_line	Black	Continuous	0.5	0.35	The line of cut for plans
0T-cut_profile	Black	Continuous	0.5	0.35	The line of cut for sections and profiles
0T-detail	Black	Continuous	0.18	0.13	Lines used to plot hard detail
	Black	Continuous	0.18	0.13	Wall tops
	Black	Continuous	0.18	0.13	Internal features in roofless buildings
	Black	Continuous	0.18	0.13	Dwarf walls under 300mm high, dashed where edge is uncertain
	Black	Dashed	0.18	0.13	The position of a wall visible as a sub-contour feature
	Black	Dashed	0.18	0.13	Roof overhangs or buttresses, walls leaning outside wall base
	Black	Dashed	0.25	0.25	Roof overhangs or buttresses, walls leaning inside wall base

Layer	Colour (Numbers in parentheses are AutoCAD colours)	Line type	Line weight (mm) Up to 1:200	Line weight (mm) 1:500 and over	Description of content
0T-footprint	Black	Continuous	0.25	0.25	Ground line, line at the base of a batter or where height of ground becomes part of the building plan
0T-grid	Black	Continuous	0.25	0.25	The grid using annotated margin marks and associated text (as per text layer); length of line not to exceed 5mm at plot scale; grid intersections to be shown by an 8mm cross
0T-grid_text	Black	Continuous	0.25	0.18	All text associated with the grid; annotation to be aligned with grid line
0T-hachure	Black	Continuous	0.18	0.18	Hachures
0T-hdge	Brown (36)	Continuous	0.18	0.13	Hedge line at ground level
0T-hgde_OL	Light brown (34)	Continuous	0.18	0.13	Outline limit of hedge spread
0T-inst_cntl	Black	Continuous	0.25	0.25	All control data with the exception of traverse lines (on layer 0T-trav) and text other than station symbol and target descriptors; datum lines indicated as a 5mm horizontal line on either side of the plotted subject with annotation in text 3mm high; plumb lines to be indicated in the same manner; station symbol to be a triangle with centre mark 3mm high
0T-level	Black	Continuous	0.25	0.18	Level point descriptor
0T-level_text	Black	Continuous	0.25	0.18	Spot levels to 2 decimal places with associated text rotated so that it is legible with all layers on; where available space forces the level or any other text to cross other lines, a break will be used to ensure clarity

Layer	Colour (Numbers in parentheses are AutoCAD colours)	Line type	Line weight (mm) Up to 1:200	Line weight (mm) 1:500 and over	Description of content
0T-overhead	Black	Dashed	0.25	0.18	Lines indicating overhead detail
0T-path	Black	Dashed	0.18	0.13	A pathway where there is no kerb or channel
0T-remote	Black	Continuous	0.25	0.18	Lines indicating information remote from the line of cut
0T-subt	Black	Dashed	0.25	0.18	To show an underground feature such as the path of a traced water course or ice house
0T-surface	Black	Dashed, dashes to be 2mm with a 1mm gap at plot scale	0.18	0.13	To delineate the outline areas of different ground treatment or material
0T-svs_d	Black	Continuous	0.18	0.18	Derived service information
0T-svs_elec	Red	Continuous	0.18	0.18	Electrical services, to be expanded as required
0T-svs_fire	Red	Continuous	0.18	0.18	Fire control services, e.g. hydrants
0T-svs_foul	Light brown (34)	Continuous	0.18	0.18	Drainage, foul; show direction of flow
0T-svs_gas	Blue	Continuous	0.18	0.18	Gas services
0T-svs_rw	Lilac (175)	Continuous	0.18	0.18	Drainage, surface water; show direction of flow
0T-svs_tele	Orange	Continuous	0.18	0.18	For telephone lines; poles to be shown; lines to be shown as an overhead detail with a dashed line
0T-svs_water	Turquoise (121)	Continuous	0.18	0.18	Water supply

Layer	Colour (Numbers in parentheses are AutoCAD colours)	Line type	Line weight (mm) Up to 1:200	Line weight (mm) 1:500 and over	Description of content
0T-text	Black	Continuous	0.25	0.18	All text except title, control text, tree data and text associated with height information; text will be positioned to avoid overwriting detail when the layer is on with all other layers
0T-title	Black	Continuous	0.35	0.25	Rubric, key, logos, north signs, scale bars and all associated text
0T-trav	Black	Continuous	0.25	0.18	Traverse lines with annotation of reduced angles, distances and station coordinates (if other than world coordinate system is used)
0T-tree	Green	Continuous	0.25	0.25	Tree bole hatched solid
0T-treeA	Green	Continuous	0.18	0.13	Canopy spread by individual tree
0T-treeB	Green	Continuous	0.18	0.13	Canopy spread trimmed to envelope
0T-treeM	Green	Continuous	0.18	0.13	Tree less than 5m in height
0T-tree_text	Green	Continuous	0.25	0.18	Tree: descriptive text
0T-veg	Dark green (96)	Continuous	0.18	0.13	Limit of vegetation, to be subdivided if needed
0T-wall_top	Black	Continuous	0.25	0.25	Lines used to describe wall tops inside the line of cut (i.e. the view of the wall looking from above) if this varies significantly from the cut line

7

Format, presentation and provision of survey data

7.1 Digital data

7.1.1 CAD filenames

All CAD filenames are to be at least eight characters in length and must comply with the following file naming system. The standard abbreviation for the site will be as noted in the project brief.

Characters	Description
1-3	Standard abbreviation of the monument name, e.g. DOV (Dover Castle)
4-5	Year survey carried out e.g. 23 (2023)
6	Type of survey
	P (photogrammetry – original images and 3-D CAD data)
	Q (photogrammetry – CAD drawing sheets)
	R (rectified photography – images and CAD files)
	O (orthophotography – images and CAD files)
	L (laser scan data)
	M (measured building survey)
	T (topographic survey)
7-8+	Sequential file number from 01. or 001 if there will be more than 99 files

For example: DOV23T01.DWG, DOV23M01.DWG.

7.1.2 CAD data format

All CAD files are to be:

- (a) either AutoCAD version 2010 .DWG
- (b) or as stated in the brief.

7.1.3 Digital image format

Digital images are to be supplied:

- (a) either as
 - the original digital images as RAW files plus uncompressed 8-bit TIFF versions
 - where the images are orthophotographs, as TIFF files
- (b) or as stated in the brief.

7.2 CAD requirements

7.2.1 Use of CAD coordinate systems

A user coordinate system (UCS) other than the world coordinate system (WCS) can be used to facilitate the presentation of the survey (or part thereof) on the desired sheet layout. Any such UCS must be saved with a name related to its function (e.g. 'SHEETVIEW' for a UCS set-up for a drawing sheet).

Where possible all height datum lines or level ticks in a drawing will have the correct height value on the vertical axis. Where two or more elevations are presented on the same drawing sheet, one above the other, then the datum lines or level ticks of the same value are to be separated by a whole number of metres.

7.2.2 Insertion point

The default origin of (0,0,0) in the WCS is to be used for xref insertions.

7.2.3 CAD drawing unit

The CAD drawing unit is to be:

- (a) either 1m
- (b) or as stated in the project brief.

7.2.4 Line type

A dashed line type is to be used for dashed lines, as opposed to using a broken line. The line type scale is to be commensurate with the plot scale so that it actually appears as a dashed line when plotted.

7.2.5 Use of paper space

- (a) Either paper space is to be used for the production of all drawing sheets and must be set up as
- 1 plotted millimetre = 1mm in paper space
 - there will be a specific paper space layout tab for each view or drawing sheet
 - the viewport(s) will be locked to prevent accidental changing of the scale
 - where elevations are presented, one above the other, in the same layout separate viewports will be employed so that the elevations remain at their true height in model space (see Section 7.2.1).
- (b) Or paper space is not to be used, and each printed drawing sheet will be represented by a unique CAD file as stated in the project brief.

7.3 Presentation

7.3.1 Drawing sheets

All drawing sheets are to be formatted on ISO A size standard sheets.

- (a) Either the client will supply the contractor with a standard sheet format (including a standard north arrow, scale bar and rubric), as a CAD file, which must be used for all plotted sheets.
- (b) Or the contractor is to prepare a suitable sheet format for approval by the client, as stated in the project brief.

See Fig. 7.1 for an example of a drawing sheet.

Where hard copy is required, each formatted CAD drawing sheet or paper space layout is to be printed. Where PDF versions are required, there is to be a separate file for each layout (see Section 7.3.6).

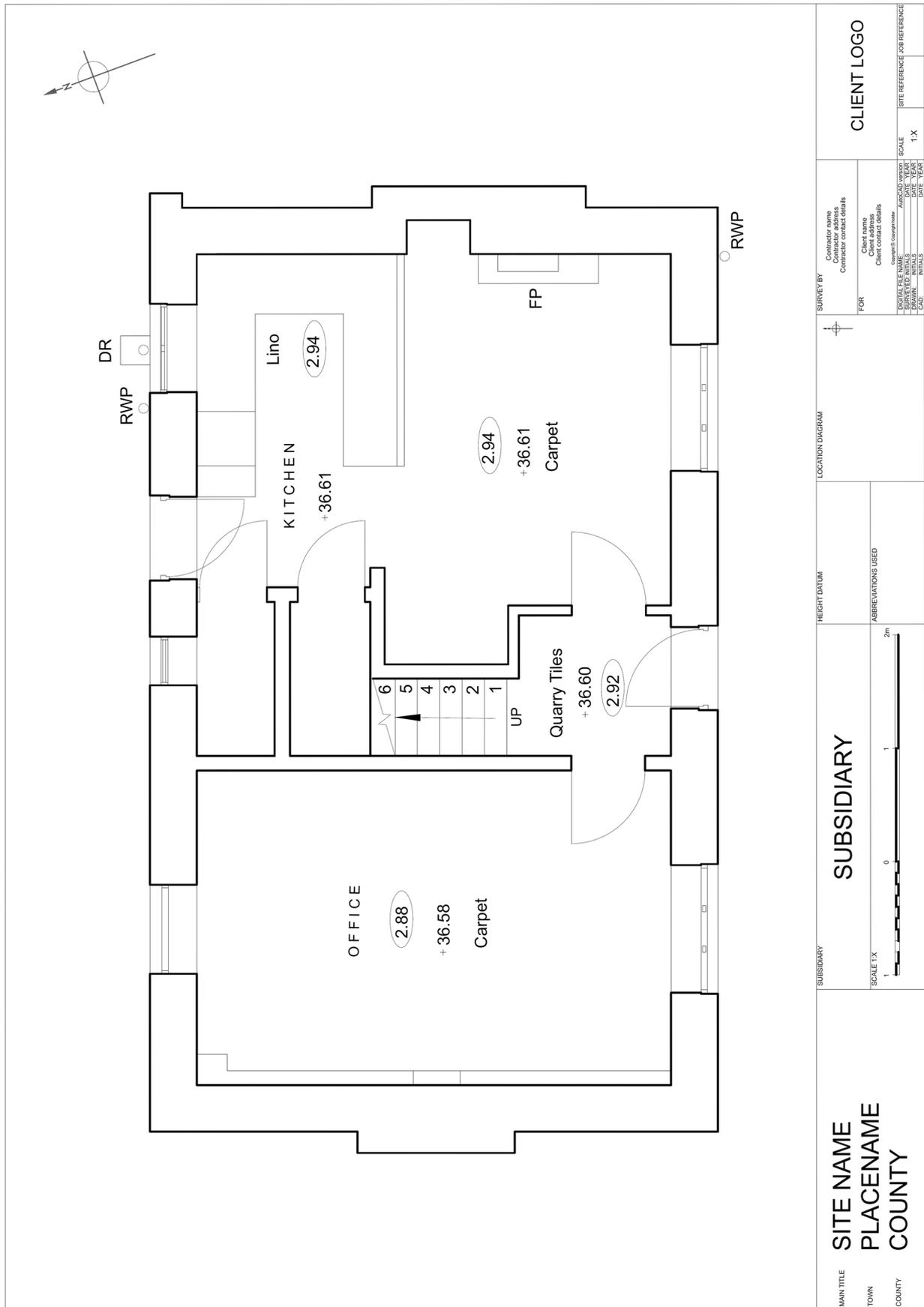


Figure 7.1: Standard drawing sheet format (with plan aligned to border).

7.3.2 Standard sheet views

Elevations and sectional elevations

Each subject to be surveyed is to be presented as an orthogonal view and, as far as is practical, all data will be presented 'square-on' to the plotted sheet. Where an elevation or image extends over more than one sheet:

- (a) either an overlap between sheets of at least 0.5m in reality is required
- (b) or the detail is to be butt jointed

as stated in the project brief.

Small registration crosses are to be printed on each sheet so that adjacent sheets can be accurately aligned.

Measured building plans

Plans are to be orientated so that north is towards the top of the sheet or the principal axes of the building are parallel to the sheet edges. Where possible, the grid will be parallel to the sheet edges. If a skewed grid is unavoidable to fit the subject logically on the sheet, then text associated with the grid must be on the same alignment as the grid with all other text aligned parallel to the sheet edge.

Topographic surveys

Topographic surveys:

- (a) either must be orientated so that north is at the top of the sheets
- (b) or may be orientated so that the detail fits the sheet and the grid is skewed

as stated in the project brief.

For all measured building plans and topographic surveys, each drawing sheet must have a north arrow. The north arrow will not clash with any detail.

7.3.3 Layout

The following project-specific information is to be included within the standard sheet layout.

- Each area surveyed is to be named correctly on the drawing sheet with reference to the actual orientation of the historic building or monument.
- Subtitles will be placed to the bottom left of the subject where possible, so that there is no risk of a title being shared by two different views. Subtitles such as 'section at AA looking west' must refer to a clearly marked key plan or accompanying plan sheet.
- A location diagram is to be included in the title box of each drawing sheet. The diagram may be schematic if necessary and should be easily understood by a third party.
- The name of the CAD file used to generate each sheet is to be included in the title box (see Section 7.1.1).
- A grid for plans and topographic surveys is to be shown as intersection points or rapier marks on the sheet edge.
- Level ticks for elevations, related to the site datum, are to be placed down each side of the drawing sheet.
- A north arrow, scale bar, height datum description or reference and a key to any abbreviations used (see Appendix 7.1) are to be included.
- Where detail extends over more than one sheet, a reference diagram of the sheet layout is required.

7.3.4 Numbering of sheets

Each sheet of the survey will have a unique reference number, starting with 1.

7.3.5 Data sheet for measured building and topographic survey

One sheet is to be the data sheet and must contain the following details:

- a control network diagram
- a sheet layout diagram
- witness diagrams for permanently marked points
- the listing of coordinates for all survey stations in eastings (X), northings (Y) and height (Z) to 3 decimal places
- a full description of height data, including benchmarks, where used, with the levels to 3 decimal places.

7.3.6 PDF drawing sheets

Where PDF versions of drawings are required, these must meet the following criteria.

- The drawing is to be at the correct scale, as noted in the title box, when printed at 100%.
- All line work is to be black except for logos, etc., in the title box, which will be their true colour.
- Each drawing sheet is to be represented by a separate PDF file, even when derived from multiple layout tabs in the same CAD drawing.
- Each file is to be named with the same file name as the CAD drawing file and with a suitable suffix if derived from multiple layout tabs, e.g. DOV23T01(01).

7.4 Survey report

A survey report is to be supplied containing a brief description of the project, plus the following:

- a traverse diagram
- witness diagrams for permanently marked points
- a listing of coordinates of all traverse stations and control points in eastings (X), northings (Y) and height (Z), to 3 decimal places.

And, where applicable:

- a photograph location diagram
- control prints
- target location diagrams
- calibration certificates.

7.4.1 Imagery metadata

Each image file is to include the following minimum level of metadata in the appropriate International Press Telecommunications Council (IPTC) and exchangeable image file format (Exif) fields:

Field	Comments
Site name	
Part of site	
List entry number	Where applicable
Project reference number	Or job number
Contractor's name	
Image number	Each image must have a unique number
Camera type	Make and model
Lens, etc.	
Exposure information	For original images
Date	Photograph captured or image created

7.5 Provision of survey material

7.5.1 Samples

- (a) Either an initial sample of the survey in the form of a PDF file and CAD file (with attached image files as appropriate) is to be provided to the client for approval before the rest of the survey is processed.
- (b) Or samples are not required, as stated in the project brief.

7.5.2 Preliminary issue

Before the final issue of CAD files, and attached imagery where applicable, a full set of preliminary PDFs is to be supplied.

7.5.3 Transfer medium

All of the required digital data and the survey report are to be supplied by:

- (a) email
- (b) and/or file transfer service
- (c) and/or a portable hard drive or solid state/flash drive.

All drives are to be suitably labelled with the project name, date and survey reference number.

Appendix 7.1 Abbreviations for survey annotation

Word(s)	Abbreviation
Aggregate	Agg
Air brick	AB
Aluminium	Al
Approximate	approx
Arch height	AH
Asbestos	Asb
Asphalt	Ap
Beam height	BH
Bitumen	Bit
Brickwork	Bk
Cast iron	CI
Ceiling	Cg
Centre line	C
Cement	Cem
Clearing eye	CE
Concrete	Conc
Corrugated	Corr
Cover level	CL
Cupboard	Cup
Diameter	Dia (state units)
Downpipe	DP

Word(s)	Abbreviation
Drain	Dr
Drinking fountain	DF
Drive shaft	D shft
Earth closet	EC
Earth rod	ER
Electricity	Elec
Fire hydrant	FH
Fireplace	FP
Floor	Flr
Grease trap	GT
Ground level	GL
Gully	G
Height	Ht
High level	HL
Inspection cover	IC
Interception trap	IT
Internal	Int
Invert	Inv
Invert level	IL
Lamp post	LP
Lightning conductor	LC

Word(s)	Abbreviation
Lath and plaster	LP
Lead	Pb
Manhole	MH
Ordnance Survey benchmark	OSBM
Overhead	OH
Petrol interceptor	PI
Radiator	Rad
Radius	Rd (state units)
Rainwater hopper	RWH
Rainwater pipe	RWP
Recessed doormat	RDM
Reinforced concrete	RC
Rising main	RM
Rainwater outlet	RWO
Rainwater pipe	RWP
Rodding eye	RE
Round	Rd
Sill	S
Site benchmark	SBM
Skirting board	Skrtg
Soffit	Soff

Word(s)	Abbreviation
Soil pipe	SP
Soil and vent pipe	SVP
Springing line	SL
Stair	Str
Stand pipe	St.P
Stone	St
Stop valve	SV
Street gully	SG
Surface level	Sfcel
Survey station	STN or STA
Temporary benchmark	TBM
Volume	Vol (state units)
Void	Vd
Wall	W
Wash hand basin	WHB
Waste pipe	WP
Water closet	WC
Width	W (state units)
Window head height	WH
Yard gully	YG



Acknowledgements

The preparation of this specification would not have been possible without the work of those, past and present, charged with the survey of the historic estate in the care of the Historic Buildings and Monuments Commission. This fourth edition has been substantially revised and re-written but is based on the original document written by Jon Bedford, Bill Blake and Paul Bryan, of the then English Heritage Metric Survey Team, with contributions from Dr David Barber and Dr Jon Mills (School of Civil Engineering and Geosciences, Newcastle University). Grateful thanks are also due to former members of the Metric Survey Team: Mick Clowes, Andy Crispe, Sarah Lunnon, Heather Papworth and Steve Tovey.

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