Design Manual for Roads and Bridges

General Principles & Scheme Governance
General Information

# GG 951
# General requirements for geomatical surveys

(formerly MCHW Volume 5 section 1 Geodetic Survey: Parts 1 – 4)

Version 1.0.0

**Summary**
This document contains the overarching requirements for the undertaking of geomatical surveys and provision of geomatic survey data.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| GG 951 | **1**.0.0 | August 2021 | Core document, England NAA | Change to policy, major revision, new document development |

This document replaces content within MCHW Volume 5 section 1 Geodetic Survey: Parts 1 - 4, that applies to surveys generically. This full document has been re-written to update the survey requirements with contemporary best-practice. This rewrite makes the content compliant with MDD drafting rules.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes relevant parts of MCHW Volume 5 Section 1 Geodetic Survey: Parts 1 – 4 that apply to surveys generically, which are withdrawn.

This document supersedes IAN 99/07, which is withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document contains overarching requirements for the undertaking of geomatical surveys and provision of geomatical survey data.

Geomatics is the discipline of gathering, storing, processing, and delivering geographic or spatially referenced information; and is principally concerned with understanding the shape and properties of the physical world.

As such, this document applies to a range of survey techniques under this discipline; and the requirements contained here are intended to be supplemented by survey-specific requirements, namely those that apply to specific techniques and associated data products.

Such requirements are to be published in related documents that reference this document accordingly. Together this forms a suite of complementary documents to meet both overarching and specific survey needs.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

# Abbreviations

| Abbreviation | Definition |
|---|---|
| GNSS | Global navigation satellite system |
| LiDAR | Light detection and ranging |
| PGM | Permanent ground marker |
| PPM | Parts per million. |

# Terms and definitions

| Term | Definition |
|---|---|
| Activity Manager | The Activity Manager coordinates the delivery of the survey by the survey contractor, in accordance with the survey specification. |
| Datum | A fixed starting point for scale measurements, typically used in reference to measuring height, that is, the location is a measured distance above/below a known datum level. |
| Geomatics | The discipline of gathering, storing, processing, and delivering geographic or spatially referenced information; principally concerned with understanding the shape and properties of the physical world. |
| Light detection and ranging | A remote sensing technique, that uses laser emitters to map spatial positions and record the reflected wavelengths and intensity of light from objects in the scene. |
| Permanent ground marker | A physical marker installed as part of a control framework, to act as a stable physical position to tie into spatial referencing systems |
| Photogrammetry | Techniques and processes used to extract information from imagery data. A predominant use of photogrammetry is the spatial positioning/measurement of objects within the image frame. |
| Survey area | The area of interest for which the survey data is required |

# 1. Scope

## Aspects covered

1.1 This document shall be applied for the undertaking of geomatical surveys and the provision of geomatical survey data.

*NOTE* *The requirements in this document apply generally, regardless of the survey techniques used.*

## Implementation

1.2 This document shall be implemented forthwith on all schemes involving the undertaking of surveys and provision of survey data on the Overseeing Organisations' motorway and all-purpose trunk roads, according to the implementation requirements of GG 101 [Ref 2.N].

## Use of GG 101

1.3 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

## Use of GG 184

1.4 Where there is a requirement in this document to create, manage, or transfer geographic vector or 3D polyline/linestring data the requirements contained in GG 184 [Ref 4.N] shall be followed.

# 2. Organisation and roles

## Definition of roles and responsibilities

2.1 Roles and responsibilities shall be agreed for each survey, including identification of those responsible and those accountable for each activity corresponding to the requirements within this document.

2.1.1 Where present, this should include identification of those responsible and accountable for any additional requirements from survey-specific documents that reference this document as a parent.

### The Activity Manager

2.2 For each implementation of this document, an Activity Manager shall be appointed.

2.3 The Activity Manager shall be responsible for the delivery of all products; including the survey data, survey report, and control report (where applicable).

2.4 The Activity Manager shall demonstrate the level of experience and competency necessary to carry out the role.

2.4.1 This level of experience should normally include a relevant qualification, post-qualified experience, and membership of a relevant professional body.

*NOTE* *Relevant professional bodies will vary with the specific survey being undertaken, accounting for the techniques and equipment involved. Examples of relevant professional bodies include:*

*1) the Royal Institution of Chartered Surveyors (RICS);*

*2) the Chartered Institution of Civil Engineering Surveyors (CICES); and,*

*3) the Institution of Civil Engineers (ICE).*

# 3. Survey specification

## Definition of survey specification

3.1 For each survey during project initialisation, a survey specification shall be defined; detailing the selected options or parameters of any requirements.

*NOTE* *The survey specification is based on the Overseeing Organisation's needs for the project. It is typically informed by the survey purpose and scope, and can include input or decisions from the customer (or their representative). The survey specification can define specifics for any requirements where a choice of options exists. Examples include:*

*1) location and area of the survey;*

*2) details or features to be surveyed;*

*3) selection of quality requirements; and,*

*4) detail of the products to be delivered.*

3.2 The definition of the survey specification shall be undertaken and/or validated by the Activity Manager, so that the proposed survey fulfils the Overseeing Organisation's needs.

# 4. Deliverables

## General

4.1 Regardless of type of geomatical survey, the following deliverables shall be provided:

1) survey report - this reflects implementation of the survey specification, comprising detail of the survey undertaken, with the addition of supporting information to provide context or background;
2) control report - required where control is used, comprising detail on the implementation and assurance of the control network; and,
3) survey data - comprising the captured data and/or processed data for the specific survey, including metadata.

4.2 Survey deliverables shall be provided in accordance with the overarching requirements detailed throughout this document.

4.2.1 Survey deliverables should be supplemented by any additional requirements that apply to the specific survey, and are detailed in other survey-specific RADs that reference this document as their base requirement.

4.3 The survey report and control report shall be provided in digital form, consisting of a number of files and types representing the requirement.

4.3.1 The survey report and control report comprise non-survey data only, which may contain numerical or textual information, geographic vector and 3D polyline/linestring information, or digital copies of other documents.

4.4 Where the survey and control reports detail location or position information, this shall be provided using the same reference system(s) as defined for the survey data.

4.5 All products to be delivered shall be structured, organised, and accompanied by suitable metadata to facilitate their association and interpretation.

## Survey report

4.6 The survey report shall include information corresponding to the requirements for the following:

1) project identification;
2) survey scope and purpose;
3) reference system(s) used throughout the project, for both:
    a) planimetric spatial position; and,
    b) vertical spatial position;
4) alternative reference transformations (if applicable);
5) survey area;
    a) spatial definition;
    b) description of conditions; and
    c) details of existing features;
6) definition of land ownership;
7) third-party services (if applicable);
8) evidence of arrangements for access;
9) survey restrictions;
10) areas in a state of change;
11) survey technique(s) employed;
12) where utilised, existing data derivatives and respective metadata and accuracies;
13) alignment with existing asset data (if applicable);

14) data retention periods; and,
15) final method statement(s)

### Control report

4.7 Where a survey control network is used, the control report shall include information corresponding to the requirements for the following:

1) survey control network diagram(s);
2) individual control locations and markers;
3) accuracy acceptance methodology;
4) observations and adjustments; and,
5) checks against the survey data accuracy requirement.

### Survey data

4.8 All survey data deliverables shall be in accordance with the survey specification, relevant to the survey type and the data sets required.

*NOTE* *The survey data can include both reference data sets and/or their derivatives depending on the survey type, the specification, the techniques used, and the desired outcome. For example LiDAR and photogrammetry (techniques) function differently and create distinctly different reference data sets; however both can be used to create similar deliverables such as point clouds, topographical data, and surface models.*

# 5. Project requirements

## Project identification

5.1 Project identification shall be defined, including:

1) project name; and,
2) project and/or contract reference number.

5.2 The project identification shall be used to identify and collate relevant information, documentation, data and files throughout the project.

## Survey purpose and scope

5.3 The scope of the project for which the survey is required shall be defined, including:

1) descriptive overview of the project;
2) purpose of the survey; and,
3) intended use of the survey information.

5.3.1 It is recommended that future use-cases should be taken into account during the scope and purpose of the survey, as the definition can be utilised beyond the immediate needs.

*NOTE* *Any data captured can be valuable to use/reuse at any stage throughout the asset management life cycle.*

# 6. Survey requirements

## Survey area

6.1 The location and extents of all areas to be surveyed shall be defined.

6.2 The survey area shall be recorded as geographic vector or 3D polyline/linestring data in accordance with the guidance within GG 184 [Ref 4.N], accompanied by any relevant metadata and notes to aid understanding.

6.2.1 Where necessary, additional information should be provided to facilitate location identification.

*NOTE* *Examples of location identification include road numbers, linear network references (sections and start/end chainages), junction references, and local place names.*

6.3 During survey planning, an accompanying description of the survey area shall be recorded, including:

1) information on the land conditions;
2) any areas/features of special significant interest to the project, such as nature reserves and third-party land; and,
3) any existing features that require special consideration for surveying, such as structures, water bodies, and historic monuments.

## Arrangements for access

### Land ownership

6.4 The location and extents of all land ownership within the survey area shall be identified.

6.5 Ownership boundaries shall be recorded as geographic vector or 3D polyline/linestring data in accordance with the guidance within GG 184 [Ref 4.N], accompanied by any relevant metadata and notes to aid understanding.

### Third-party services

6.6 Survey activities shall conform with all requirements of any third-party (private or public) service providers involved, as far as any activity that interacts with their assets and facilities is concerned.

*NOTE* *Survey activities do not constitute permission to disregard the legitimate interests of other statutory bodies or third-parties.*

6.7 A record of any identified third-party services and supplies within the survey area shall be maintained throughout the project, including:

1) service type (that is gas, electric, drainage and the like);
2) service location; and,
3) name and contact details for the owner.

6.8 Where applicable, known services shall be recorded as geographic vector or 3D polyline/linestring data, in accordance with the guidance within GG 184 [Ref 4.N], accompanied by any relevant metadata and notes to aid understanding.

### Arrangements for access

6.9 Where any survey activity requires access to or interferes with any third-party land, property, or services, arrangements shall be made with all owners/occupiers to agree with them all routes and means of access, including:

1) planned details of the access/interaction, such as routes for access;
2) dates and times of access; and,
3) process for identification of personnel.

6.9.1 All owners/occupiers should be contacted in writing, notifying them of the reason, stating approximate dates/times of the activity, and requesting their engagement to arrange routes for access.

6.9.2 Some services may only be accessed by the statutory undertaker responsible.

6.10 A record of all arrangements for access shall be maintained for the duration of the project, stating:

1) the location(s);
2) the owner/occupier, including contact information; and,
3) any details of the access arrangement.

## Restrictions to the survey

6.11 The survey shall be planned and carried out in accordance with any restrictions identified in the list in clause 6.12.

6.12 Any restrictions to the survey shall be identified and reported to the Activity Manager, including:

1) access routes to the whole survey area, or sections of the survey area;
2) the days or hours of working;
3) the overall programme or sequencing of the works;
4) imposed by traffic management arrangements;
5) due to other works in the area; and,
6) due to environmental or ecological constraints.

*NOTE* *Examples of other works referred to in 5) above include other surveys, operations and maintenance activities, traffic management, or construction works.*

6.13 A record of any restrictions shall be maintained for the duration of the project, including:

1) the location(s) of the restriction;
2) the date(s) and time(s) the restriction applies; and,
3) other nature/details of the restriction.

## Traffic management

6.14 Any activities undertaken on the network shall be conducted in accordance with the relevant requirements for working within live traffic (see TSM Chapter 8 2020 [Ref 5.N]).

6.15 Processes for lane booking/network occupancy shall be undertaken in accordance with the Overseeing Organisation's requirements for network access, as defined within DMRB GM 702 2020 [Ref 3.N].

6.16 Liaison to arrange traffic management shall be undertaken with all affected highways authorities.

## Removing obstructions to features

6.17 Survey planning shall account for any areas/features that require clearing of obstructions (such as temporary objects and vegetation) to complete capture.

6.17.1 An ecologist should be consulted if the clearance of vegetation can impact ecological habitats, flora and fauna.

6.18 All activities to clear obstructions shall be recorded, including details of:

1) location(s);
2) activity time(s);
3) where relevant, agreement with owner/occupier;
4) any name and contact details of party responsible for the clearing activity; and,
5) any details of the clearing activity required.

6.19 Where clearing of obstructions involves land/property not owned by the Overseeing Organisation, this shall be agreed with the relevant owner/occupier as part of the "arrangements for access".

6.20 Any instances where need for clearing has been identified but either agreement is lacking, or agreement has been made to take no action, or clearance has not been authorised, shall be recorded under the survey restrictions.

## Other contacts

6.21 Any other contacts that are considered relevant to the survey activity shall be identified throughout the project.

6.21.1 Typically, other relevant contacts may be related to other authorities or asset owners, including:

1) local police;
2) rail authorities;
3) highway authorities; and,
4) river and drainage authorities.

# 7. Spatial referencing systems

## Planimetric and vertical referencing

7.1 All survey data shall be aligned to a spatial reference system, as follows:

1) planimetric spatial position - referenced to a specific coordinate grid system; and,
2) vertical spatial position - referenced as orthogonal height (in metres) above/below a specific vertical datum.

7.2 A single pair of reference systems (planimetric and vertical) shall be used for any location information for all deliverables; that is all survey data and any supporting data for the project (such as definition of survey area, land ownership extents, location of restrictions, and similar).

### Coordinate transformation

7.3 Where relevant, any additional transformation to alternative referencing systems shall be defined.

## Coordinate grids

7.4 Selection of a coordinate grid shall consider the location, scale, and accuracy requirements of the survey, with options including:

1) geographic coordinate system, such as global coordinate grid;
2) projected coordinate systems, such as the national grid; and,
3) an arbitrary local grid system, such as a local grid for a specific geographic area, or a site grid specific to the project.

*NOTE* *The scale and geographic location of the survey are of particular importance when selecting the coordinate system. When surveying a large area, and/or linking multiple data sets, geodetic coordinate systems - those that acknowledge the shape and curvature of the earth - can be necessary for survey data to meet consistent spatial quality requirements.*

## Datum

7.5 Selection of a datum shall consider the the location, scale, and accuracy requirements of the survey.

# 8. Survey control network

## Control network implementation

8.1 Where required to achieve the project's accuracy requirements, plan and vertical control networks shall be used.

8.2 Survey control points shall be established, to realise this control network grid on the ground, using a system of primary, secondary, and tertiary control points.

*NOTE* *For example, a control network can comprise:*

*1) primary control points located nominally 1000 m, and no less than 500 m, apart;*

*2) secondary control points located nominally 250 m, and no less than 100 m, apart;*

*3) tertiary control points at a scale suitable to the detail and required accuracy of the survey; and,*

*4) additional levels of control as required (as per tertiary).*

8.2.1 Each survey control location should be positioned and selected so as to assure intervisibility to other points in the control network, facilitating observations and measurements between control points.

8.3 Physical Ground Markers (PGMs), shall be used to indicate primary control locations.

8.3.1 Other markers or control stations, such as temporary locations or markers, may be used to indicate secondary, tertiary, and lower-order control locations.

8.4 A control network diagram shall be provided, detailing the location and layout of the control network used, including:

1) location(s);
2) type and sub-type of control/marker such as permanent ground marker, temporary marker;
3) date of installation and/or last validation such as new control, or validation of existing control;
4) where possible, for constructed markers, ground surface type/marker construction type;
5) photographs of control sites; and,
6) any notes or annotation to provide context on the location or situation of the marker.

8.5 The control network diagram shall be recorded as geographic vector or 3D polyline/linestring data, in accordance with GG 184 [Ref 4.N], accompanied by any relevant metadata and notes to aid understanding.

## Control markers

### Physical ground markers (PGMs)

8.6 Physical ground markers shall be selected and installed as suitable for the location and context.

*NOTE* *For examples of physical control markers refer to Appendix A.*

8.6.1 PGMs should be installed so as to ensure their long-term stability (more than five years), free from disturbance or other influence.

8.7 Where PGMs are proposed for installation on third-party land/property, the owner's permission shall be sought to agree installation, placement, and to ensure that the marker will be undisturbed for its lifespan.

8.8 Where installation of new control markers is required, they shall be implemented in such a way to promote and optimise their future reuse.

### Reuse of control markers

8.9 Where available, suitable, and compliant with the requirements contained within this document, existing control markers shall be reused.

## Accuracy acceptance criteria

8.10 Where a survey control network is established it shall be designed, observed, adjusted, and checked to achieve both the plan and height accuracy level(s) required for the data products.

8.10.1 Observations should be such that there is sufficient geometric resilience and redundancy to assess the control accuracy.

8.11 Control shall be designed, observed, calculated, adjusted, and checked so that direct distance between control points, calculated from adjusted coordinates, is within the error tolerances indicated below:

**Table 8.11 Adjacent control point error tolerance.**

| | **For adjacent points 0-200 m apart** | **For adjacent points 200+ m apart** |
|---|---|---|
| Primary control | error less than ±2 mm | error less than 1 in 100,000 |
| Secondary control | error less than ±3 mm | error less than 1 in 75,000 |
| Tertiary control | error less than ±3 mm | error less than 1 in 50,000 |

8.12 The height difference between any two points used as primary control points shall not be in error by more than ±(12√k) mm, where k is the distance in kilometres between the points being considered, or ±3 mm, whichever is the greater.

8.13 The accuracy requirement for tertiary and lower order control shall be dependent on their intended use.

8.14 A record shall be provided detailing the process to assure control accuracy, including:

1) accuracy acceptance methodology;
2) observations and adjustments; and,
3) results of checks against the data accuracy requirement.

# 9. Data capture

## New data capture

9.1 A record of all techniques used to capture survey data shall be maintained, including:

1) the derivation, such as on-site GNSS measurements, and LiDAR imagery,
2) platform(s) if used, such as vehicle, drone, fixed/rotary wing aircraft;
3) the date of capture;
4) the survey or sensor equipment used, including manufacturer, model, specification; and,
5) any calibration certificates or maintenance records for the survey equipment.

9.1.1 The survey technique, equipment and platform should be chosen in order to meet the survey requirements.

*NOTE* *Combinations of survey technique, equipment, and platform are suitable to fulfil different survey specifications, depending on various factors including the selected features, scale of the survey, terrain, access arrangements, and other restrictions on the survey.*

## Use of existing reference data sets

9.2 Where existing reference data is available, it shall be assessed to establish if it is relevant and accurate to the requirement.

*NOTE* *For some survey types, existing reference data sets could be available, providing coverage (in part or full) of the survey area. This facilitates the processing/derivation of the deliverables without the need for new data capture, potentially providing efficiencies and cost-savings to the survey project.*

9.2.1 The existing reference data sets should be assessed for suitability, primarily regarding:

1) the temporal relevance, that is when were the data captured and if it is still relevant; and,
2) the data quality, that is, the completeness and accuracy of the data.

9.2.2 Existing reference data should be used if it is shown to meet the survey specification.

9.3 Where existing reference data sets are used a record shall be maintained, including:

1) the origin of the data;
2) the type of data, for examples LiDAR, and aerial imagery;
3) the date of capture;
4) owner of the data set;
5) data quality specification; specifically, completeness and accuracy of the data;
6) details of any post-processing or data manipulation;
7) where possible, the survey equipment used including manufacturer, model, specification;
8) where possible, any calibration certificates for the survey equipment; and,
9) agreement of suitability to the survey.

## Areas in a state of change

9.4 Any area that is in a state of change at the time of survey, that is undergoing activity to change, update, or remove features, shall be recorded.

9.5 The extents of any area of change shall be recorded as geographic vector or 3D polyline/linestring data, in accordance with GG 184 [Ref 4.N], accompanied by any relevant metadata and notes to aid understanding.

9.6 For each area, details of the type of change it is undergoing shall be recorded, including;

1) description of change (for example construction work); and,
2) date at which change is expected to be complete (best-estimates if direct information is not available).

9.6.1 Where areas of significant change are known, or can can be identified during survey planning, these should be discussed with consideration to remove from the survey area or list in the survey restrictions.

# 10. Data quality

## Defining survey data quality

10.1 Data quality requirements shall be in accordance with the survey specification.

10.1.1 Typically, requirements for survey data quality should comprise:

1) completeness - that is, does the quantum of the data cover the requested survey scope?; and,
2) spatial accuracy - that is, do the recorded positions of data provided have accurate alignments to their real-world positions?

10.2 Data quality requirements shall be defined in accordance with survey-specific requirements.

10.2.1 Different survey data sets may have different parameters and levels to both define and measure quality, depending on the techniques and data sets required.

10.3 Any survey data delivered shall meet the quality requirements defined in the survey contract.

## Quality validation

10.4 All survey data provided shall be subject to any validation processes applied on receipt of the data deliverables, to ensure quality requirements are met.

10.4.1 The relevant validation processes should be discussed at project initialisation.

# 11. Data management

## Alignment with existing prime asset data

11.1 Where relevant, any alignment of survey data sets with existing asset data sets shall be in accordance with the survey specification.

*NOTE* *For any specific requirements, giving detail of the data sets, systems, and processes, refer to the relevant National Application Annex(es) to this document.*

## Data retention

11.2 The responsibility and period(s) for data retention shall be in accordance with the survey specification.

11.2.1 Different data sets may have different retention periods.

11.3 Data shall be retained for the period defined, in accordance with the survey specification.

### Statutory limitations

11.4 All data capture, handling, and retention must be undertaken in accordance with EU General Data Protection Regulations, GDPR 2016 [Ref 1.N].

## Data security

11.5 All handling, storage, and transfer of data shall be undertaken in accordance with the Overseeing Organisation's requirements for data security.

# 12. Methodology

## Method statement

12.1 The proposed survey methodology shall be approved by the Activity Manager, before any survey is undertaken.

12.2 The methodology shall be planned in accordance with all requirements within this document.

# 13. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Publications Office of the EU. Council of the European Union, European Parliament. GDPR 2016, 'General Data Protection Regulation (EU) 2016' |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 3.N | Highways England. GM 702, 'Operational requirements for network occupancy' , 2020 |
| Ref 4.N | Highways England. GG 184, 'Specification for the use of Computer Aided Design' |
| Ref 5.N | TSO. TSM Chapter 8, 'Traffic Signs Manual Chapter 8 - Traffic Safety Measures and Signs for Road Works and Temporary Situations' , 2020 |

# Appendix A. Control markers

## A1 Physical ground markers

Examples of physical ground markers, used for different surface types:

**Figure A.1 Rivet marker - suitable for concrete or stone surfaces; cross-section (left) / plan (right).**

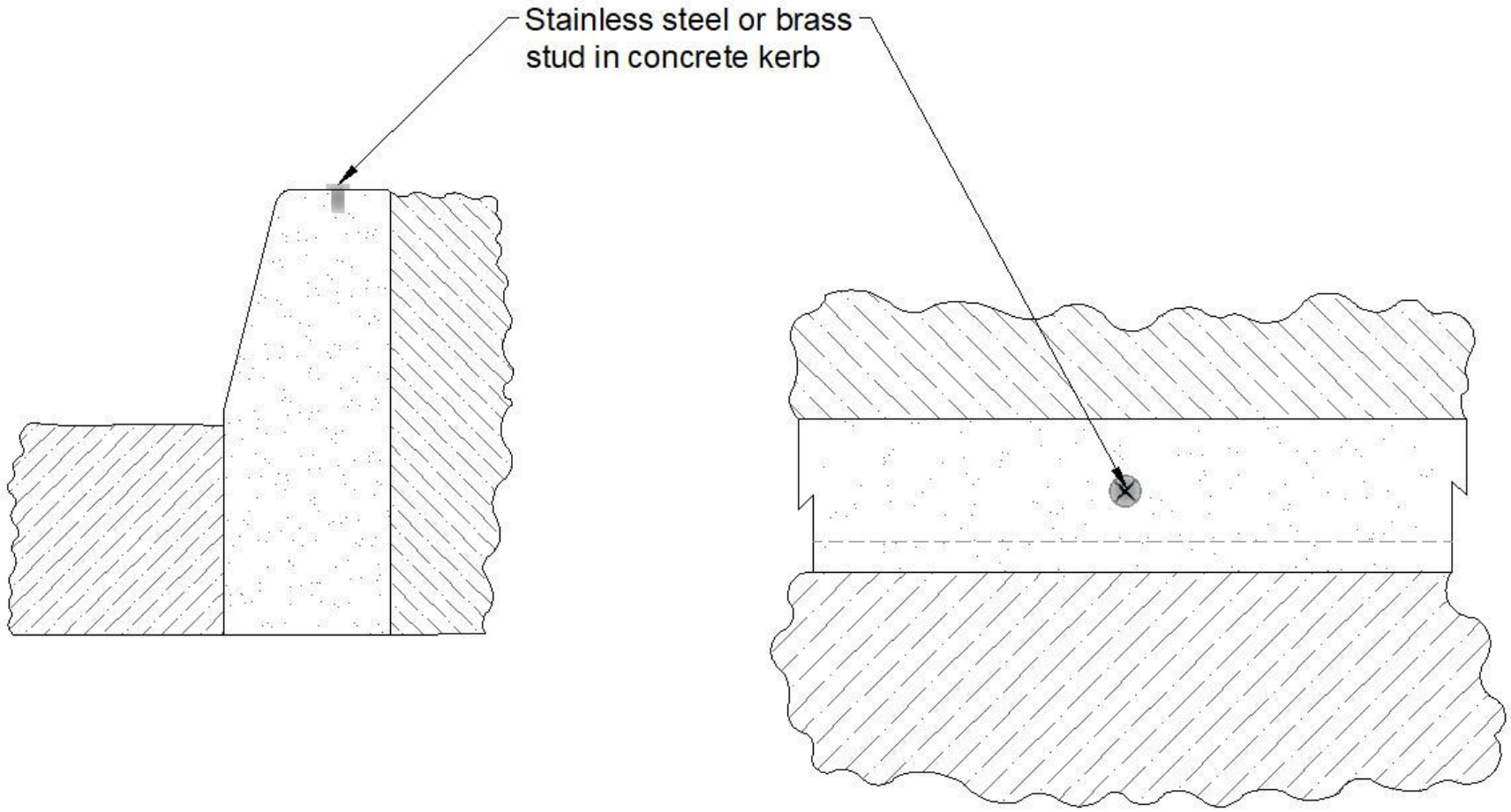


**Figure A.2 Type 1 marker - suitable for dense, very stable surfaces (e.g. pavements); cross-section (left) / plan (right).**

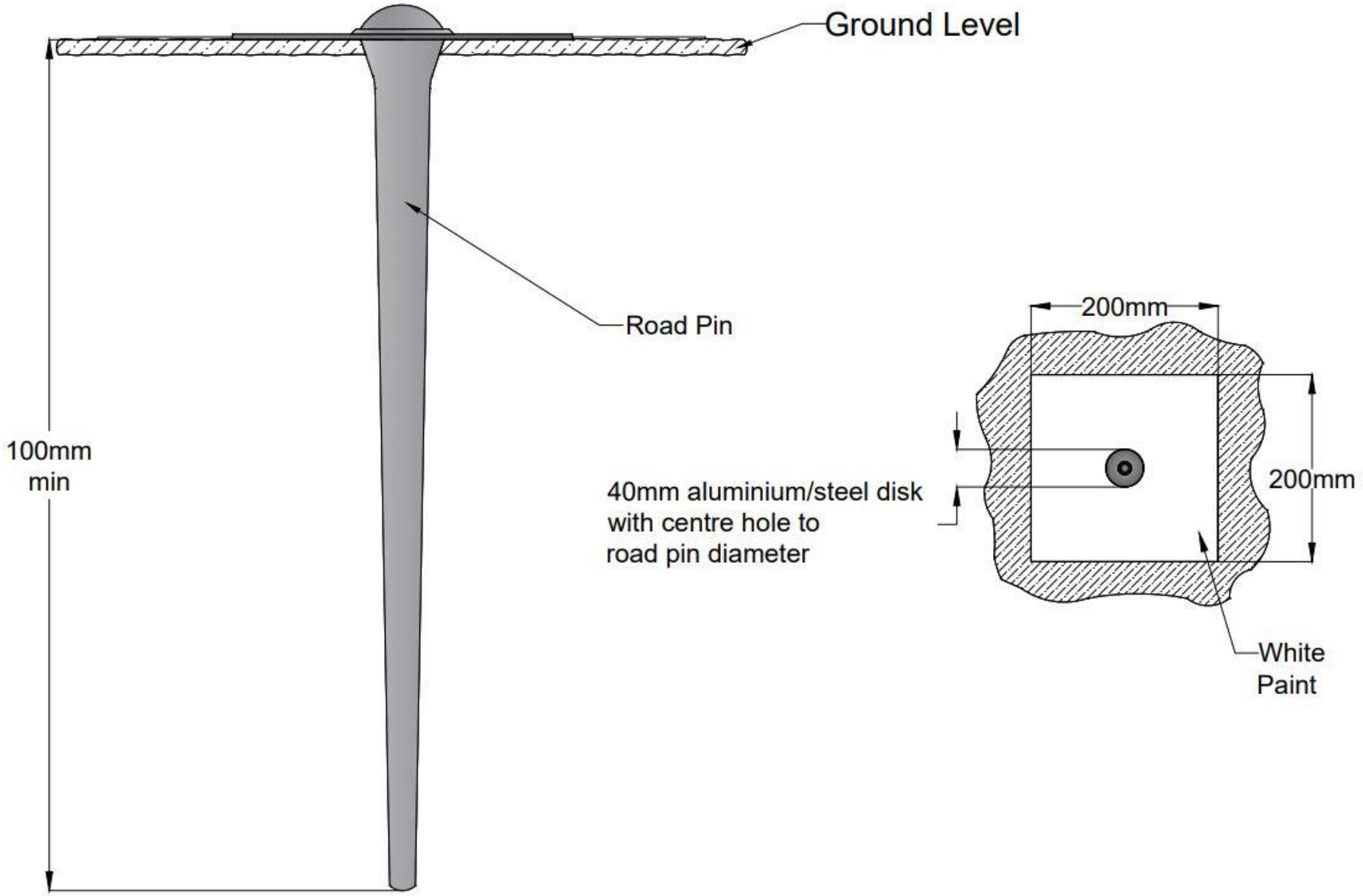


**Figure A.3 Type 2 marker - suitable for non-agricultural sites and unpaved surfaces; cross-section (left) / plan (right).**

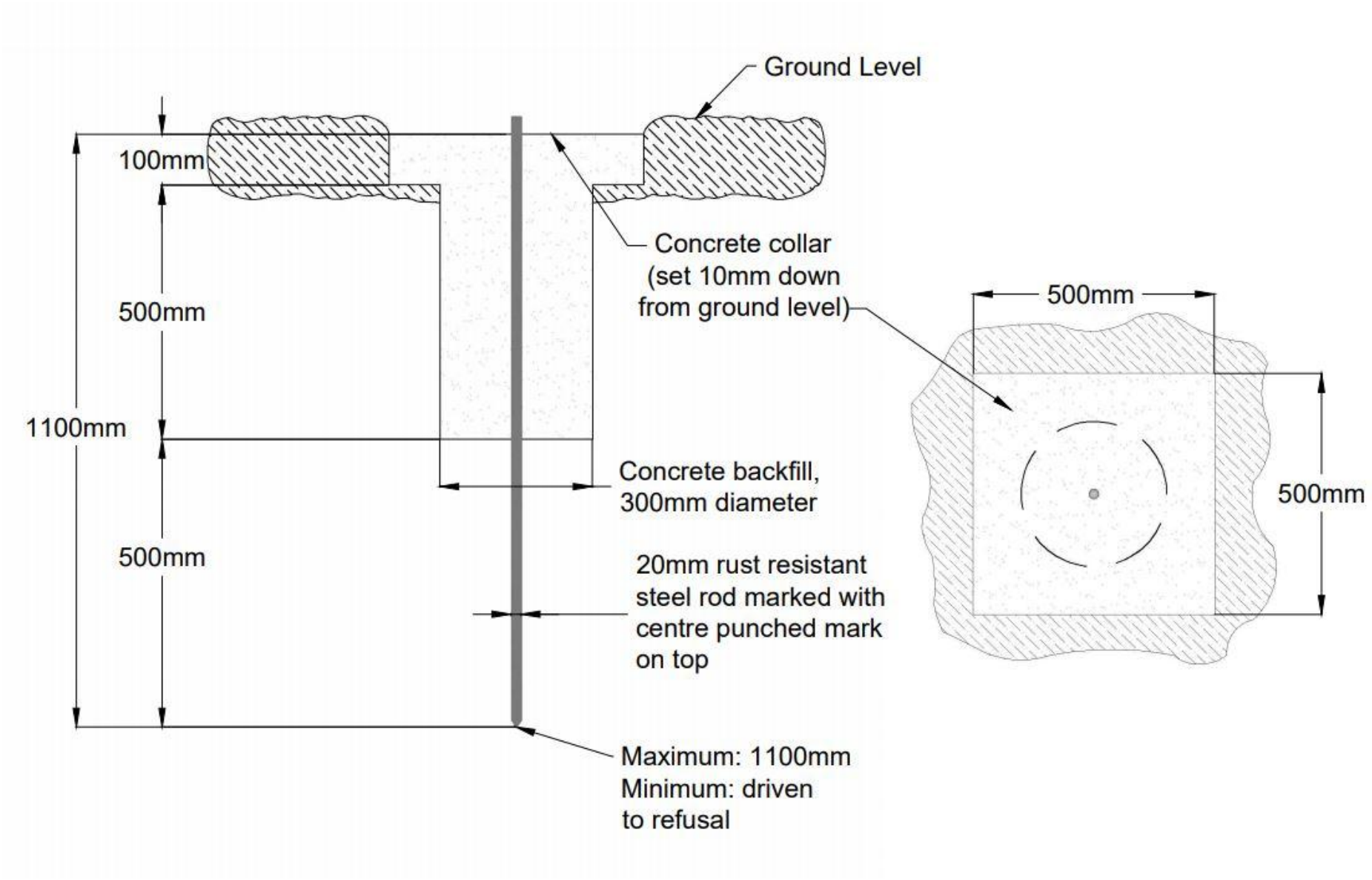


**Figure A.4 Type 3 marker - suitable for agricultural sites; cross-section (left) / plan (right).**

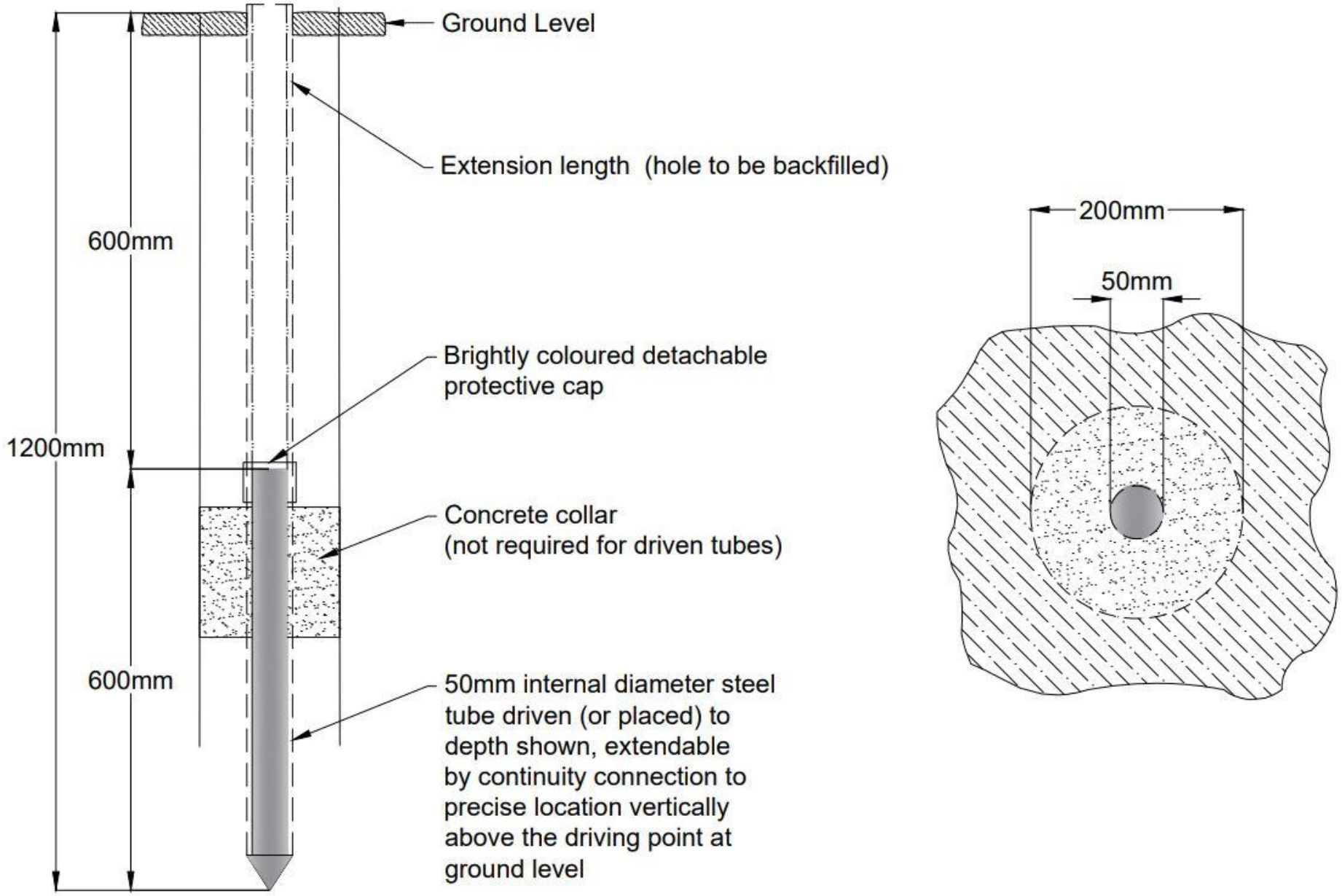
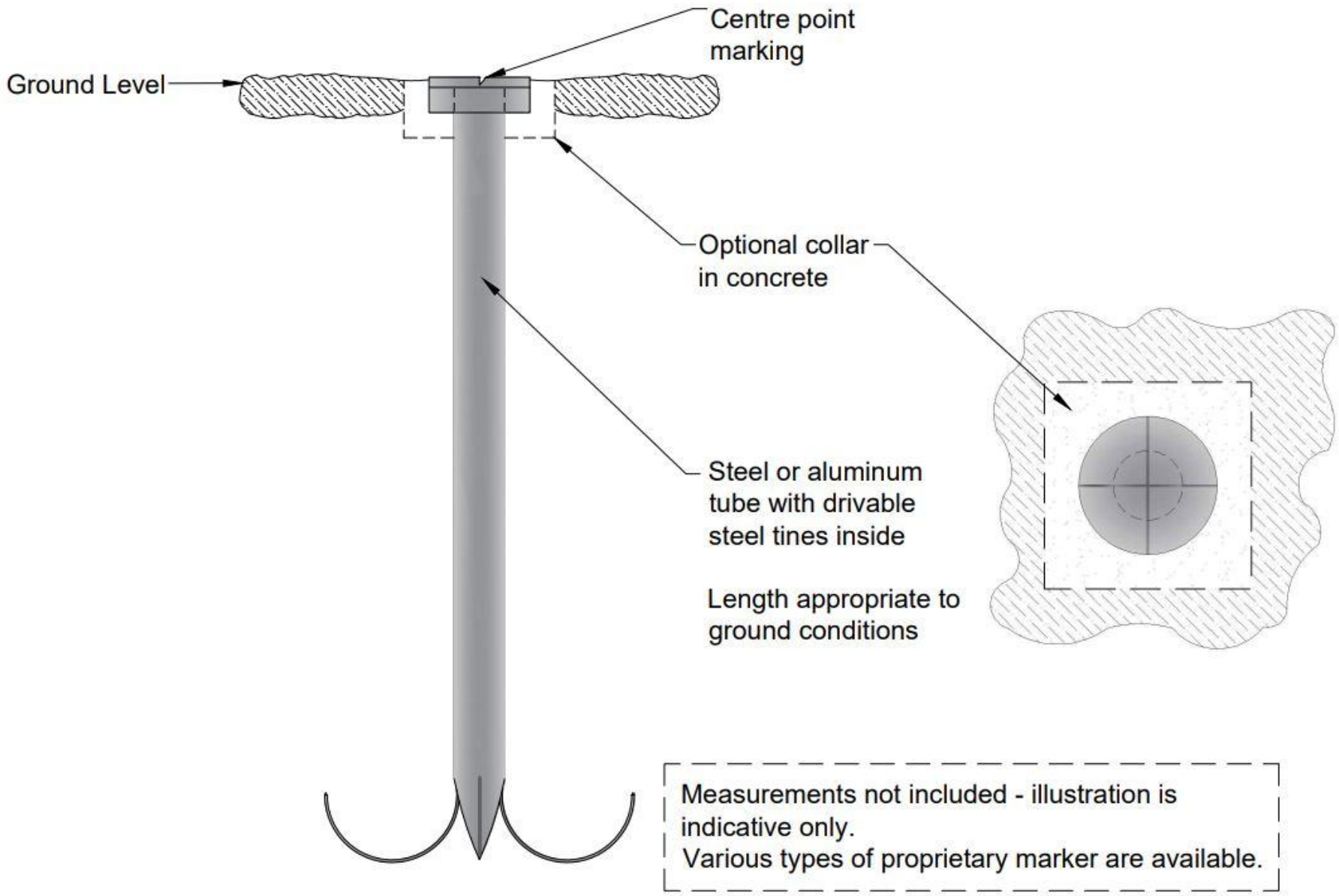


**Figure A.5 Type 4 marker - suitable for soft surfaces; cross-section (left) / plan (right).**



General Principles & Scheme Governance
General Information

# GG 951
# England National Application Annex to GG 951 General requirements for geomatical surveys

(formerly IAN 99/07)

Version 1.0.0

**Summary**
This National Application Annex contains the Highways England-specific additional requirements for the application and transposition of local and national grid referencing systems for England for delivering survey data, and the management of survey data with respect to asset data.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| GG 951 | **1**.0.0 | August 2021 | England NAA | Change to policy, major revision, new document development |
| New Highways England National Application Annex to GG 951. | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes MCHW Vol 5 Section 1 Part 2 SD 12/96 Section 5.2.4, which is withdrawn.

This document supersedes IAN 99/07, which is withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives Highways England-specific supplementary requirements for the overarching requirements for geomatical surveys.

#### Coordinate referencing systems

This National Application Annex gives the Highways England-specific additional requirements for the application and transposition of local and national grid referencing systems for England for surveys using GG 951 or scheme-specific documents.

This document ensures that surveys are referenced to a series of standardised local grids across England. This will ensure survey data can be converted between local grid and Ordnance Survey National Grid in a standardised way and that the method of data conversion is not lost with the survey report.

In many cases, the Ordnance Survey National Grid referencing system of easting and northing coordinates is used with height values quoted above Ordnance Datum, Newlyn (AOD) to reference survey data. However, this national coordinate system for the whole of England is a mapping projection of the transverse Mercator type. Using a projection introduces inaccuracies when undertaking detailed design, and construction, which need to be considered for accuracy in terms of a local non-projected grid.

#### Data management

This National Application Annex gives the Highways England-specific reqrequirements for managing survey data, in respect to alignment with existing asset data sets held by the company.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

# Abbreviations and symbols

| Abbreviation | Definition |
|---|---|
| ADMM | Highways England's Asset Data Management Manual |
| AOD | Above Ordnance Datum |
| CSF | Combined scale factor |
| ESF | Elevation scale factor |
| LocalE | Local grid easting |
| LocalN | Local grid northing |
| OrgE | Origin easting |
| OrgN | Origin northing |
| OsE | Ordnance Survey easting |
| OsN | Ordnance Survey northing |
| PSF | Projection scale factor for zone |

# Terms and definitions

| Term | Definition |
|---|---|
| Combined scale factor | Factor used to convert Ordnance Survey grid coordinates to local grid coordinates. |
| Elevation scale factor | Factor used to correct for computational errors resulting from the curvature of the earth and the height above sea level. |
| Geomatics | The discipline of gathering, storing, processing, and delivering geographic or spatially referenced information; principally concerned with understanding the shape and properties of the physical world. |
| Height banding | Elevation range of a site for which a designated elevation scale factor is applied. |
| Highways England local grid layout | The layout of a standardised local grid coordinate system as shown in E/2. |
| Local grid zone | A zone within the Highways England local grid. |
| Ordnance Datum (Newlyn) | An industry-standard vertical datum for establishing height/altitude for mapping data, used by Ordnance Survey in Great Britain. |
| Ordnance Survey National Grid | Geographic grid reference system (OSGB36), used by the Ordnance Survey in Great Britain. |
| Zone projection scale factor | Factor used to correct for computational errors resulting from the curvature of the earth and horizontal curvature. |

# E/1. Scope

## Background [GG 951, 1.1]

E/1.1 This document shall be used to ensure all geomatical surveys are referenced to a series of standardised local grids across England.

*NOTE Employing local grid transformation(s) ensures consistent referencing throughout.*

## Implementation [GG 951, 1.2]

E/1.2 This document shall be implemented on all geomatical surveys being carried for all projects where a local grid is required.

*NOTE 1 This document is not applicable to surveys being carried out to Ordnance Survey National Grid coordinates.*

*NOTE 2 Applying a standardised local grid ensures consistent transformations between local and national grid systems, facilitating the integration of surveys from any suppliers across all schemes and ensuring interoperability of survey data across the Highways England motorway and all-purpose trunk roads network.*

# E/2. Local grid parameters [additional to GG 951]

## Zones and projection scale factors

E/2.1 The appropriate local grid zone(s) used shall be selected using Table E/2.1, below:

**Table E/2.1 Local grid zones, origins, projection scale factors and height banding**

| Zone | Zone Start E | Zone Start N | Zone Origin E | Zone Origin N | Projection SF | Height bands |
|---|---|---|---|---|---|---|
| A1 | 148000 | 29000 | 138000 | -171000 | 1.000354 | 1 |
| A2 | 157000 | 29000 | 147000 | -171000 | 1.000300 | 1 |
| A3 | 166000 | 29000 | 156000 | -171000 | 1.000249 | 1,2 |
| A4 | 175000 | 39000 | 165000 | -171000 | 1.000199 | 1 |
| A5 | 184000 | 39000 | 174000 | -171000 | 1.000149 | 1,2 |
| A6 | 194000 | 39000 | 184000 | -171000 | 1.000098 | 1,2 |
| A7 | 204000 | 59000 | 194000 | -171000 | 1.000050 | 1,2 |
| A8 | 214000 | 39000 | 204000 | -171000 | 1.000001 | 1,2 |
| A9 | 225000 | 39000 | 215000 | -171000 | 0.999952 | 1,2 |
| A10 | 237000 | 39000 | 227000 | -171000 | 0.999901 | 1,2 |
| A11 | 251000 | 39000 | 241000 | -171000 | 0.999847 | 1,2,3 |
| A12 | 266000 | 39000 | 256000 | -171000 | 0.999797 | 1,2,3 |
| A13 | 282000 | 59000 | 272000 | -171000 | 0.999749 | 1,2 |
| A14 | 299000 | 79000 | 289000 | -171000 | 0.999700 | 1,2 |
| A15 | 322000 | 79000 | 312000 | -171000 | 0.999647 | 1,2 |
| A16 | 356000 | 79000 | 346000 | -171000 | 0.999602 | 1,2 |
| A17 | 434000 | 98000 | 424000 | -171000 | 0.999633 | 1,2 |
| A18 | 468000 | 98000 | 458000 | -171000 | 0.999686 | 1,2 |
| A19 | 498000 | 98000 | 488000 | -171000 | 0.999740 | 1,2 |
| A20 | 515000 | 98000 | 505000 | -171000 | 0.999788 | 1,2 |
| A21 | 532000 | 98000 | 522000 | -171000 | 0.999843 | 1,2 |
| A22 | 549000 | 98000 | 539000 | -171000 | 0.999906 | 1,2 |
| A23 | 566000 | 98000 | 556000 | -171000 | 0.999958 | 1,2 |
| A24 | 575000 | 98000 | 565000 | -171000 | 1.000001 | 1,2 |
| A25 | 586000 | 98000 | 576000 | -171000 | 1.000049 | 1,2 |
| A26 | 596000 | 98000 | 586000 | -171000 | 1.000097 | 1,2 |
| A27 | 606000 | 119000 | 59600 | -171000 | 1.000147 | 1,2 |
| A28 | 616000 | 119000 | 606000 | -171000 | 1.000198 | 1,2 |
| A29 | 625000 | 119000 | 615000 | -171000 | 1.000248 | 1 |
| A30 | 634000 | 119000 | 624000 | -171000 | 1.000300 | 1 |
| B15 | 322000 | 239000 | 312000 | -211000 | 0.999647 | 1,2,3 |
| B16 | 356000 | 239000 | 346000 | -211000 | 0.999602 | 1,2,3,4 |

**Table E/2.1 Local grid zones, origins, projection scale factors and height banding** (continued)

| Zone | Zone Start E | Zone Start N | Zone Origin E | Zone Origin N | Projection SF | Height bands |
|---|---|---|---|---|---|---|
| B17 | 434000 | 239000 | 424000 | -211000 | 0.999633 | 1,2 |
| B18 | 468000 | 239000 | 458000 | -211000 | 0.999686 | 1,2 |
| B19 | 498000 | 239000 | 488000 | -211000 | 0.999740 | 1 |
| B20 | 515000 | 239000 | 505000 | -211000 | 0.999788 | 1 |
| B21 | 532000 | 239000 | 522000 | -211000 | 0.999843 | 1 |
| B22 | 549000 | 239000 | 539000 | -211000 | 0.999905 | 1 |
| B23 | 566000 | 239000 | 556000 | -211000 | 0.999958 | 1 |
| B24 | 575000 | 239000 | 565000 | -211000 | 1.000000 | 1 |
| B25 | 586000 | 239000 | 576000 | -211000 | 1.000049 | 1 |
| B26 | 596000 | 239000 | 586000 | -211000 | 1.000097 | 1 |
| B27 | 606000 | 239000 | 596000 | -211000 | 1.000147 | 1 |
| B28 | 616000 | 239000 | 606000 | -211000 | 1.000198 | 1 |
| B29 | 625000 | 239000 | 615000 | -211000 | 1.000247 | 1 |
| B30 | 634000 | 239000 | 624000 | -211000 | 1.000299 | 1 |
| B31 | 643000 | 278000 | 633000 | -211000 | 1.000353 | 1 |
| B32 | 652000 | 278000 | 642000 | -211000 | 1.000408 | 1 |
| C13 | 282000 | 498000 | 272000 | -226000 | 0.999748 | 1 |
| C14 | 299000 | 458000 | 289000 | -226000 | 0.999700 | 1,2,3,4 |
| C15 | 322000 | 449000 | 312000 | -226000 | 0.999647 | 1,2,3,4,5 |
| C16 | 356000 | 449000 | 346000 | -226000 | 0.999602 | 1,2,3,4 |
| C17 | 434000 | 449000 | 424000 | -226000 | 0.999633 | 1,2 |
| C18 | 468000 | 449000 | 458000 | -226000 | 0.999686 | 1,2 |
| C19 | 498000 | 449000 | 488000 | -226000 | 0.999740 | 1,2 |

*NOTE 1* *The start point of each zone is the bottom left hand corner of each zone. The origin point of each local grid zone is the Ordnance Survey National Grid coordinates of the zero/zero point of each local grid zone.*

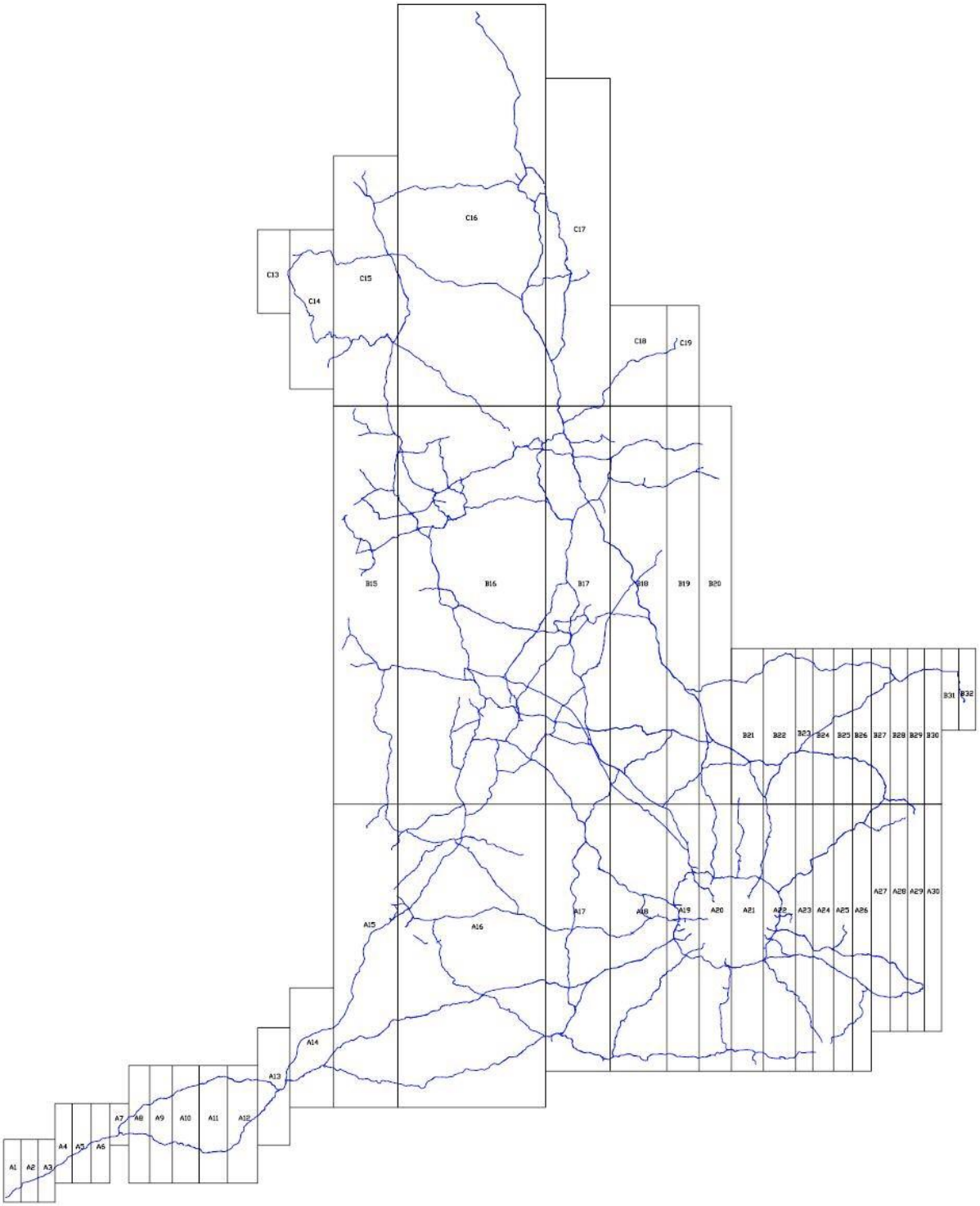
*NOTE 2* *The origin coordinates have been selected to ensure the local grid values have a 6-figure easting value and a 5-figure northing value. Both values are therefore distinct and different to the Ordnance Survey National Grid.*

*NOTE 3* *The local grid zone boundaries have been manipulated to fit with the motorway and all-purpose trunk roads network. The design minimises road crossing zones, particularly in the north/south direction.*

*NOTE 4* *Local grid zones have been developed to limit scale factor errors to less than 50 mm per 1 km. Further information on scale factor errors and the development of local grid zones is provided in Appendix E/A1.1.*

*NOTE 5* *A graphical representation of Highways England Local Grid Layout for England is shown below in Figure E/2.1N5.*

**Figure E/2.1N5 Highways England Local Grid Layout for England**




*NOTE 6* *The widths of the zones vary according to the location of zone within the national mapping projection of Great Britain.*

*NOTE 7* *A digital version of Figure E/2.1N5 is available to download underneath this document on the DMRB website GG 953 [Ref 1.I].*

E/2.2 Where data is recorded between zones the data shall be split at the zone boundary or may be adjusted

by up to 1 km from the zone boundary.

E/2.3 When data is recorded between zones and the split of E/2.2 would have data with negative local coordinates, the local origin shall be amended 1 km to the west and 1 km to the south.

*NOTE* *The local origin shifts to the west and south are to be applied together for consistency. This ensures all coordinates are positive.*

## Height bands

E/2.4 The appropriate local height band value shall be selected using Table E/2.4 below.

**Table E/2.4 Local Grid Zone Height Banding Value (please refer to OD Newlyn datum for first three columns)**

| Elevation Band | | Mean Elevation | Elevation Scale Factor | Height Band | Alternative Height Band |
|---|---|---|---|---|---|
| -160 | 0 | -80 | 1.0000125 | Band 0 | |
| -80 | 80 | 0 | 1.0000000 | | Band 0A |
| 0 | 160 | 80 | 0.9999875 | Band 1 | |
| 80 | 240 | 160 | 0.9999750 | | Band 1A |
| 160 | 320 | 240 | 0.9999625 | Band 2 | |
| 240 | 400 | 320 | 0.9999500 | | Band 2A |
| 320 | 480 | 400 | 0.9999375 | Band 3 | |
| 400 | 560 | 480 | 0.9999250 | | Band 3A |
| 480 | 640 | 560 | 0.9999125 | Band 4 | |
| 560 | 720 | 640 | 0.9999000 | | Band 4A |
| 640 | 800 | 720 | 0.9998875 | Band 5 | |

*NOTE 1* *For example, a survey site with a mean site elevation of 55 m would be Band 1, as would a site at 155 m.*

*NOTE 2* *Appropriate data sets typically exclude data outside the site boundary which affect the mean site height.*

*NOTE 3* *The elevation band values are typical values and can be deemed to include values plus or minus 8 m.*

E/2.4.1 The height bands 0-5 should be used where possible with alternative height bands 0A-4A used only where appropriate and recorded.

*NOTE* *Where a scheme straddles the standard height band the alternative height band (0A-4A) can be used to ensure a better fit with the data.*

## Conversion formulae

E/2.5 The combined scale factor (CSF) shall be computed using the appropriate zone projection scale factor (PSF) and the elevation scale factor (ESF) used by each height band in accordance with Equation E/2.5.

**Equation E/2.5 Combined scale factor equation**

$$CSF = PSF \times ESF$$

where:

| | |
|---|---|
| CSF | is the Combined scale factor |
| PSF | is the Zone projections scale factor |
| ESF | is the Elevation scale factor |

E/2.6 The local grid shall be computed from the Ordnance Survey National Grid using the Equation E/2.6a and Equation E/2.6b below.

**Equation E/2.6a Local Grid easting equation**

$$LocalE = \frac{OsE - OrgE}{CSF}$$

where:

| | |
|---|---|
| LocalE | = Local grid easting |
| OsE | = Ordnance Survey easting |
| OrgE | = Origin easting |
| CSF | = Combined scale factor |

**Equation E/2.6b Local Grid northing equation**

$$LocalN = \frac{OsN - OrgN}{CSF}$$

where:

| | |
|---|---|
| LocalN | = Local grid northing |
| OsN | = Ordnance Survey northing |
| OrgN | = Origin northing |
| CSF | = Combined scale factor |

*NOTE* *An example of the calculation of the combined scale factor is shown in Appendix E/A3.*

E/2.7 A procedure to shift an entire drawing on the Ordnance Survey National Grid system to the local grid shall be performed, as below:

1) take the spatial data to be transformed and insert a suitable Ordnance Survey permanent ground marker coordinate near the area (for quality control checking);
2) shift the spatial data by the relevant Origin easting and Origin northing given in Table E/2.1 above;
3) save this as a drawing block;
4) open the local grid drawing/model and import the saved block;
5) scale x and y ONLY by the reciprocal of the combined scale factor for the appropriate local grid zone; and,
6) check the local grid coordinates of the control point to ensure transformation has been achieved correctly.

E/2.8 When converting from local grid to Ordnance Survey National Grid, the inverse of the procedure outlined above shall be performed.

### Zone naming

E/2.9 Each zone shall be named as the appropriate zone and height banding.

E/2.10 An asterix shall be applied to denote a change to the origin coordinates as described in E/2.4.

*NOTE* *For example a zone name is B16H3*.*

E/2.11 The zone name used shall be recorded with the survey data.

*NOTE* *The recording method can be in metadata of the survey itself or a survey report.*

# E/3. Data management

## Alignment with existing prime asset data [GG 951, 10.1]

E/3.1 Alignment of survey data sets with prime asset data shall be in accordance with the requirements, processes, and procedures contained within the current version of the ADMM (current version) [Ref 1.N].

*NOTE* *The Overseeing Organisation can hold existing prime asset data, specifically data that is the single, principle, source of information within the business, for the area being surveyed. Where new survey data potentially replicates information held in this prime data set, it is recommended that data comparison, validation, and update are arranged to:*

*1) avoid duplicate data entering the company; and,*

*2) ensure any changes/improvements are integrated into the prime data set.*

# E/4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. ADMM, 'Asset Data Management Manual' , (current version) |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

# E/5. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | www.standardsforhighways.co.uk/dmrb/. Highways England. GG 953, 'GG 953 Local grid layout for England digital map' |

# Appendix E/A. Examples

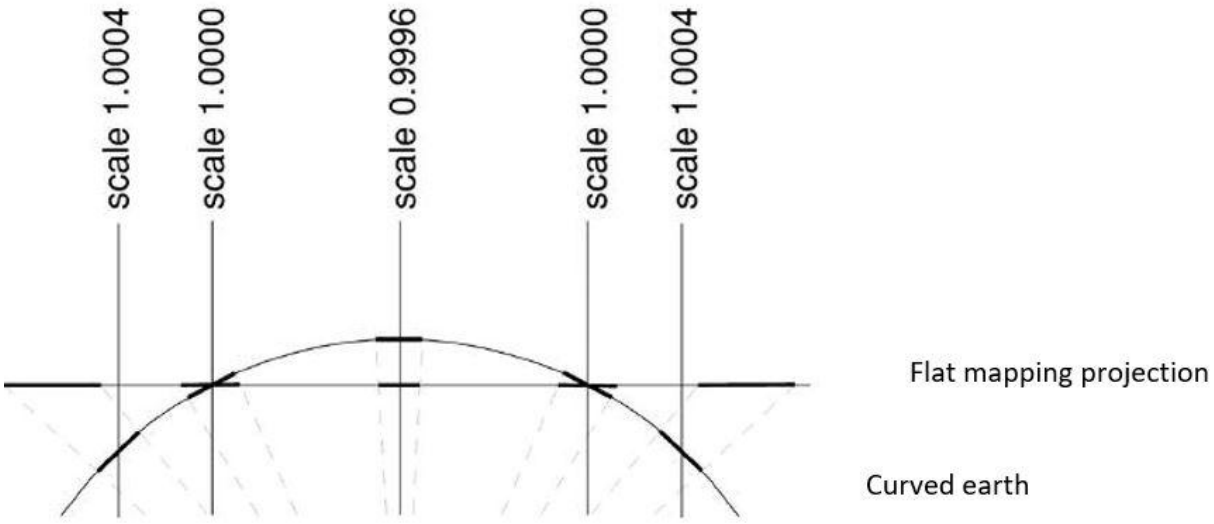
## E/A1 Local grid zone development and scale factor errors

### E/A1.1 Background

Measurements from Ordnance Survey National Grid coordinates, or any other national mapping system, contain factual errors. These are variable according to where the measurements are made within the mapping projection.

The map projection represents a 3D surface on a 2D plan. In locations east and west from the tangent points the scale becomes greater or smaller.The reason is due to the shape of the mapping projection which can be seen in Figure E/A.1 below.

**Figure E/A.1 Scale distortions caused by mapping projection, cross section view**




In order to overcome the scale factor of the mapping projection the country has been split into a series of local grid zones. These are variable in width from some 9km wide at the east and west extremes of the country in East Anglia and Cornwall. However the central zone covers some 78 km as it spans the central meridian of the country. The diagram showing the variable widths can be seen in Figure E/2.1N5. All the local grid parameters and zone definitions can be found in Table E/2.1 and Table E/2.4.

The widths of the local grid zones are such that the maximum distortion is kept below 5 cm per 1 km. That is to say, a distance measured between two points and their local grid coordinates will be correct to the ground distance to within 0.05%.

### E/A1.2 Scale factor error example

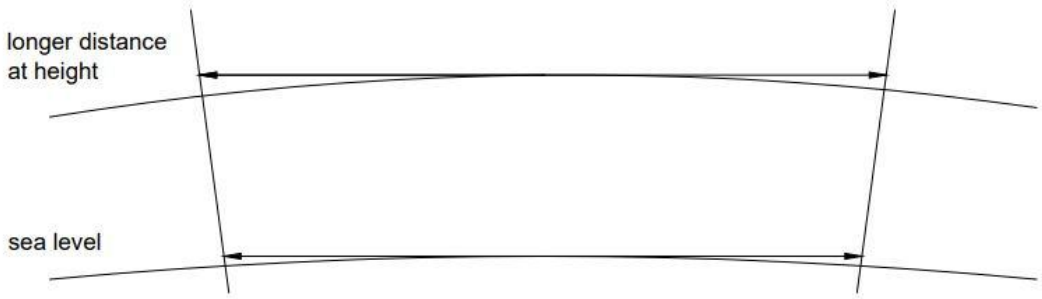
The true ground distance between two drainage gullies on the M25, near Junction 28, might be 256.45m.The distance between the two gullies measured from the difference in their coordinates in the Ordnance Survey National Grid mapping projection at this point would be 256.39m. Therefore, measurements at this point in the mapping projection are too short. This is due to the scale factor of the mapping projection being some 0.999762 at this location.

Using local grid zones, the true ground distance of 256.45m will be 256.45m ±0.01m in the local grid. In this case, the mapping projection data is scaled up in the local grid and made larger to fit the true earth. However, at the east/west extremities of England the mapping projection data is scaled down to fit the true earth, where the scale is in excess of 1.0000.

## E/A2 Site height errors

In addition to the scale factors caused by the mapping projection in England, the site height also causes an effect. With a site at sea level, that is with a site height of 0m above Ordnance Datum Newlyn, any distances measured on the ground will be the same as those measured within the local grid; within the 0.05% accuracy explained above. However, as the site height increases, the true distances measured on the ground increases with respect to those measured at sea level. This effect is caused by the curvature of the earth and the fact that the points on the earth are slightly further apart the higher up the points become. An exaggerated view is shown in Figure E/A.2 below.

**Figure E/A.2 Scale distortions caused by site heights, cross section**




A series of height bands has been generated with a spacing to keep distortion due to height below 0.05%. This ensures that the distances measured from the local grid coordinates of points are accurate to those measured on site, depending to the site height. The height bands can be found in Table E/2.1, the formulae and method of generating the combined scale factor for each zone can be seen in Equation E/2.5 and the section which follows Table E/2.1 and Table E/2.4.

The site height can affect measured distances, for example a distance of 1 km measured at 100 m above sea level will be 2 cm shorter when reduced to sea level.

A site with a mean site height of 100 m falls within height Band 1 and the mapping projection data is also scaled up by 0.9999875 to fit the true earth distance measurements at this height thereby restricting the distortion due to height.

## E/A3 Worked example

For a site at 345 m along the M62, the appropriate zone is B16 and the height band is 3.

The Ordnance Survey National Grid coordinates of the point in the zone are, for example;

397895 E, 414760 N, 350 AOD.

These can be converted to the equivalent local grid values using the following steps:

**Equation E/A.1 Combined scale factor equation**

$$CSF = 0.999602 \times 0.9999375 = 0.9995395$$

**Equation E/A.2 Local grid easting equation**

$$LocalE = \frac{397895 - 346000}{0.9995395} = 51918.907E$$

**Equation E/A.3 Local grid northing equation**

$$LocalN = \frac{414760 + 211000}{0.9995395} = 626048.279N$$

Department for Infrastructure
An Roinn Bonneagair

General Principles & Scheme Governance
General Information

# GG 951
# Northern Ireland National Application Annex to GG 951 General requirements for geomatical surveys

(formerly SD12/96)

Version 1.0.0

**Summary**
There are no specific requirements for the Department for Infrastructure, Northern Ireland supplementary or alternative to those given in GG 951.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| GG 951 | **1**.0.0 | August 2021 | Northern Ireland NAA | Change to policy, major revision, new document development |
| New Northern Ireland National Application Annex to GG 951 | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|

# NI/1. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

General Principles & Scheme Governance
General Information

# GG 951
# Scotland National Application Annex to GG 951 General requirements for geomatical surveys

(formerly SP12/96)

Version 1.0.0

**Summary**
There are no specific requirements for Transport Scotland supplementary or alternative to those given in GG 951 core document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| GG 951 | **1**.0.0 | August 2021 | Scotland NAA | Change to policy, major revision, new document development |
| New Scotland National Application Annex to GG 951 | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|

# S/1. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

Llywodraeth Cymru
Welsh Government

General Principles & Scheme Governance
General Information

# GG 951
# Wales National Application Annex to GG 951 General requirements for geomatical surveys

(formerly SP12/96)

Version 1.0.0

**Summary**
There are no specific requirements for the Welsh Government supplementary or alternative to those given in GG 951 core document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| GG 951 | **1**.0.0 | August 2021 | Wales NAA | Change to policy, major revision, new document development |
| New Wales National Application Annex to GG 951 | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|

# W/1. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |