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Client Report for

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| Victorian Survey Control Requirements  Specifications for installing and enhancing survey control infrastructure |
| Surveyor-General Victoria - Geodesy |
| December 2022 - Edition 1 |

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Surveyor-General Victoria - Geodesy

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Author

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Photo credit

Differential levelling survey in Box Hill to establish survey control mark infrastructure for the Suburban Rail Loop.

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| |  | | --- | | Acknowledgment  We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.  We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond. | | © The State of Victoria Department of Environment, Land, Water and Planning 2022  LogoThis work is licensed under a Creative Commons Attribution 4.0 International licence. You are free to re-use the work under that licence, on the condition that you credit the State of Victoria as author. The licence does not apply to any images, photographs or branding, including the Victorian Coat of Arms, the Victorian Government logo and the Department of Environment, Land, Water and Planning (DELWP) logo. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>  Disclaimer  This publication may be of assistance to you but the State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.  Accessibility  If you would like to receive this publication in an alternative format, please telephone the DELWP Customer Service Centre on 136186, email [customer.service@delwp.vic.gov.au](mailto:customer.service@delwp.vic.gov.au), or via the National Relay Service on 133 677 [www.relayservice.com.au](http://www.relayservice.com.au). This document is also available on the internet at [www.delwp.vic.gov.au](http://www.delwp.vic.gov.au). | |

Revision history

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# Introduction

The availability of accurate and reliable survey control mark infrastructure and information is a fundamental component in all surveying projects. Survey control mark infrastructure and information support:

* surveying of property boundaries
* all phases of the project cycle (planning, design, construction, as-constructed, etc.)
* ongoing monitoring
* future surveying and spatial activities
* alignment with other spatial information
* increased survey efficiency and reduced duplication of effort.

Victoria has a state-wide network of survey control marks, also referred to as permanent marks. These survey control marks hold accurate coordinate and height information aligned to the national datums and provide a stable point of reference for surveying and spatial activities.

A suitable survey control mark network is required to be established and maintained to support all infrastructure and development projects. The type of monumentation and distribution of survey control mark infrastructure depends on project requirements. In addition, the control survey between survey control marks will be designed to ensure coordinate and height information meet project survey uncertainty and positional uncertainty requirements.

The purpose of this document is to specify requirements for the maintenance and enhancement of survey control mark infrastructure and information for all projects. General requirements are specified for the monumentation and distribution of survey control mark infrastructure, conduct of control surveys and submission of this information for integration in the Victorian Survey Control Network (SCN) and Victorian Levelling Network (VLN). This will ensure projects are completed in accordance with survey legislation and standards, as well as support ongoing surveying and spatial activities in Victoria.

## Scope

This document outlines Surveyor-General Victoria (SGV) requirements for:

* maintenance of existing survey control marks
* installation of survey control marks within and around projects, specifically the
  + type of monumentation, and
  + their distribution (number and spacing)
* control surveys to establish survey control marks
* submission of information for inclusion in the Victorian SCN and VLN.

This document is intended to support specification of survey control requirements in project contracts for:

* major infrastructure projects – transport, water, utilities, etc.
* property development – new estates of 10 lots or more
* airborne remote sensing projects – imagery, LiDAR.

## Communication

All enquiries, data and support information submissions related to this document are to be directed to

SGV Geodesy. Email: [SMES.Support@delwp.vic.gov.au](mailto:SMES.Support@delwp.vic.gov.au)

## Disclaimer

These requirements are intended to help authorities, organisations and surveyors fulfil their legislative requirements and good practice principles in the ongoing maintenance and enhancement of the Victorian survey control mark network. Surveyors are expected to exercise professional judgement when applying these specifications in the context of broader project requirements.

# References

## Legislation and directives

These requirements have been prepared to support public authorities, organisations and surveyors to satisfy obligations to establish and maintain suitable survey control mark infrastructure within and around project areas.

These obligations are specified in the following legislation and directives:

*Survey Co-ordination Act 1958*, No. 6388/1958

Survey Co-ordination Regulations 2014, S.R. No. 39/2014

Surveying (Cadastral Surveys) Regulations 2015, S.R. No. 43/2015

SGV (2021), *Victorian Cadastral Surveys Practice Directives*, Edition 2, Surveyor-General Victoria, Victoria, Australia.

## Standards and guidelines

These requirements are aligned to the Intergovernmental Committee on Surveying and Mapping standards and guidelines for the maintenance and enhancement of Australia’s survey control network.

The following standards and guidelines are referred to throughout these requirements.

ICSM (2020), *Standard for the Australian Survey Control Network – Special Publication 1*, Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

ICSM (2020), *Guideline for the Installation and Documentation of Survey Control Marks*, Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

ICSM (2020), *Guideline for Control Surveys by GNSS*, Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

ICSM (2020), *Guideline for Conventional Traverse Surveys*, Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

ICSM (2020), *Guideline for Control Surveys by Differential Levelling*, Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

ICSM (2020), *Guideline for the Adjustment and Evaluation of Survey Control,* Version 2.2, Intergovernmental Committee on Surveying and Mapping, Canberra, Australia.

# Datum

The datum is the national spatial reference standard for all surveying and spatial information. Alignment with the national datum ensures seamless integration of spatial information from many and varied sources, including foundational spatial information managed by national and state government agencies.

Survey control marks **must** be coordinated relative to the national datums set out in Section 2 of the ICSM SP1 Standard for the Australian Survey Control Network v2.2. These are the Geocentric Datum of Australia 2020 (GDA2020) and the Australian Height Datum 1971 (AHD71).

## Geocentric Datum of Australia 2020 (GDA2020)

Three-dimensional coordinates are to be expressed in terms of GDA2020 with respect to the GRS80 reference ellipsoidal.

Horizontal coordinates are to be expressed in terms of the Universal Transverse Mercator (UTM) projection of GDA2020, the Map Grid of Australia 2020 (MGA2020) Zones 54 and 55 in Victoria.

## Australian Height Datum 1971 (AHD71)

Orthometric heights are to be expressed in terms of AHD71 (or AHD) as determined by direct connection to AHD heights of local VLN adjusted survey control marks within or adjacent to the project area.

When deriving AHD heights from GDA2020 ellipsoidal heights the AUSGeoid2020 model **must** be used.

# Survey control uncertainty

Survey control mark horizontal coordinates and height uncertainties are to be quantified and evaluated in relation to survey uncertainty and positional uncertainty as described in ICSM SP1 Standard for the Australian Survey Control Network v2.2 and ICSM SP1 Guideline for the Adjustment and Evaluation of Survey Control v2.2.

The ICSM SP1 Standard for the Australian Survey Control Network v2.2 and associated guidelines describe surveying equipment, measurement techniques and processing strategies to achieve survey uncertainties specified by the project.

Common survey control uncertainties are included below for survey uncertainty and positional uncertainty.

## Survey uncertainty

The uncertainty of the horizontal coordinates or height of a survey control mark relative to the survey in which it was observed. Survey uncertainty reflects only the uncertainty resulting from survey measurements, measurement precisions, network geometry and the choice of constraint. Generally derived from a minimally constrained least squares adjustment. It is expressed at the 95% confidence level.

Table 1: Example survey uncertainty to be specified in project requirements

| Example survey uncertainty | | | |
| --- | --- | --- | --- |
| < 2 mm | < 10 mm | < 20 mm | < 50 mm |

## Positional uncertainty

The uncertainty of the horizontal coordinates or height of a survey control mark with respect to the defined datum. This is a combination of the survey uncertainty and uncertainty in the connection to datum through existing survey control marks or GNSS ground stations. Derived from a fully constrained least squares adjustment. It is expressed at the 95% confidence level.

Table 2: Example positional uncertainty to be specified in project requirements

| Example positional uncertainty | | | |
| --- | --- | --- | --- |
| < 10 mm | < 20 mm | < 50 mm | < 100 mm |

* It is commonly accepted that project requirements may only specify survey uncertainty. This acknowledges the project primary focus on survey agreement within the project survey control network which will be treated as fixed constraint for all subsequent survey activities.

# Survey control mark infrastructure

Survey control mark infrastructure is required to be maintained and enhanced to support project development and construction, ongoing monitoring and future surveying and spatial applications.

The survey control mark network provides physical reference points for surveying activities and ensures subsequent spatial information is aligned to the national datums.

## Survey control mark monumentation

### Permanent marks

Permanent marks (PMs) are survey control marks intended to support all phases of the project cycle and any ongoing monitoring and future surveying activities in the surrounding area.

Permanent marks are required to be installed and recorded in accordance with ICSM SP1 [Guideline for Installation and Documentation of Survey Control Marks v2.2](https://www.icsm.gov.au/sites/default/files/2020-12/Guideline-for-Installation-and-Documentation-of-Survey-Control-Marks_v2.2.pdf).

This corresponds with Regulations 4 and 5 of the Survey Co-ordination Regulations 2014 which specifies a permanent mark **must** be:

* of a durable, permanent and stable construction and material; and in the form of a monument in Schedule 1
* established where it is in the most stable location and least likely to be subject to damage, disturbance or removal or to constitute a hazard
* facilitating horizontal and vertical connections to existing and future marks
* readily identifiable and easy to find.

Permanent mark information **must** be registered in the online Survey Marks Enquiry Service (SMES) as per Regulation 6 and 7 of the Survey Co-ordination Regulations 2014.

Table 3: Example types of permanent marks

| Example types of permanent marks | Notes |
| --- | --- |
| High stability mark | Deep-seated marks are recommended in projects where the monument stability is critical such as deformation monitoring or precision engineering. |
| Plaque set in pre-cast concrete block or in situ | Standard and most common monument. Should be installed as part of project construction work, such as for new estate developments and major infrastructure projects. |
| Plaque set in existing stable concrete structure (e.g. pit surround) | Only suitable in built-up areas (such as CBD), where it is not possible to install other permanent mark types. |

### Temporary benchmarks

Temporary benchmarks (TBM) can be established within and around the project area as stable points of reference for operational survey activities such as monitoring, feature surveys and construction set out.

Acknowledging that TBMs may be destroyed during construction activities, lower quality survey monuments such as nails, rivets and star iron pickets are acceptable. However, these lower quality survey monuments are not suitable for inclusion in SMES as permanent marks.

Table 4: Example types of temporary benchmarks

| Example types of temporary benchmarks | | | |
| --- | --- | --- | --- |
| Nail | Rivet | Deck spike | Star picket |

## Survey control mark distribution

A suitable distribution of survey control marks is required to support all infrastructure and development projects. The project survey control mark network will feature a combination of permanent marks and temporary benchmarks. The number, distribution and spacing of these survey control marks depends on project requirements including:

* size and shape of the project area
* location of critical features
* survey techniques being employed
* survey control uncertainty requirements
* any planned deformation monitoring
* any additional project specific requests.

The minimum number of permanent marks and spacing requirements for different surveying projects are specified below.

Table 5: Minimum permanent marks and spacing requirements

| Surveying project | Minimum number of permanent marks | Permanent mark spacing |
| --- | --- | --- |
| Major infrastructure projects | 3 | 500 m – 1000 m \* |
| New estate developments | 3 | 100 m – 500 m |
| Larger area airborne remote sensing projects | 5 | 5 km – 10 km |

\* Permanent mark spacing for long linear projects in rural areas may be increased to 2 km – 5 km.

### Major infrastructure projects

Major infrastructure projects involve the development of large-scale infrastructure assets usually owned by the Victorian Government and include major transportation (road, rail, air and sea ports), major utilities (e.g. power, water) and other major public construction projects (e.g. hospitals, sport and culture precincts). The project survey control mark network for major infrastructure projects **must** consist of at least three (3) permanent marks, existing or newly established, within or near the project area. Additional, survey control marks may be required depending on project requirements and to accord with permanent mark distribution requirements in Table 5.

If the project includes an element of deformation monitoring, there may be a need to establish additional permanent marks outside the project area and potential zone of influence (e.g. subsidence due to tunnelling, structural monitoring).

### New estate developments

Local Government Authorities set requirements for the establishment of permanent marks in new estate developments. The number of permanent marks required is as per regulation 11(3) of the Surveying (Cadastral Surveys) Regulations 2015 and is based on the number of lots in the new estate, with a minimum of three (3) permanent marks and additional permanent marks if there are 10 or more lots at ground level. Permanent marks are usually installed in footpaths at road intersections, as part of civil construction works. This supports ongoing accessibility and line of sight observations.

A TBM is equivalent to a primary cadastral mark (PCM) in a cadastral survey. Section 2.6 of the Victorian Cadastral Surveys Practice Directives July 2021 provides further information on establishing PCMs in a cadastral survey.

### Airborne remote sensing projects

At least five (5) permanent marks are required for airborne remote sensing projects (such as imagery and LiDAR) and they should be distributed around the spatial extents of the project area, with at least one mark central to the project area. For large project areas, additional permanent marks may be required to adhere with the survey control mark spacing requirements provided in Table 5.

## Process to establish survey control mark network

### Assess existing permanent mark network

Before commencing a project, assess the existing permanent mark network within and around the project area.

* Review SMES and conduct field site inspection
* Identify existing permanent marks within the Victorian SCN and VLN to support connection to datum (GDA2020/AHD).
  + Contact SGV Geodesy for additional support, if required.
* Identify existing permanent marks within project area that are to be protected and included in project survey control mark network.
* Identify existing permanent marks within project area that will be destroyed as part of project works, as per Regulations 8 of the Survey Co-ordination Regulations 2014.
  + SGV Geodesy **must** be contacted to discuss remediation – may require survey to preserve permanent mark information (e.g. AHD height connection).
  + SMES **must** be updated with details of mark disturbance or removal.

### Design and installation of survey control marks

Design and install the project survey control mark network and integrate with the existing permanent mark network.

* Survey control marks are required to be installed in accordance with Section 3 of the ICSM SP1 [Guideline for Installation and Documentation of Survey Control Marks v2.2](https://www.icsm.gov.au/sites/default/files/2020-12/Guideline-for-Installation-and-Documentation-of-Survey-Control-Marks_v2.2.pdf).
* Determine suitable survey control mark monumentation, in accordance with Section 5.1, taking into consideration project requirements, environment, geology, etc.
* Identify placement of additional permanent marks and temporary benchmarks, in accordance with Section 5.2
  + Ensure site safety for surveying activities and general public
  + Consider ongoing site access requirements during and after project construction
  + Consider distribution inside and outside project area
  + Consider connection to existing permanent mark network
  + Consider sky-visibility for GNSS observation and possible intervisibility for terrestrial observations
  + Confirm site suitability – Before You Dig Australia (BYDA), authority asset search
* Install permanent marks and temporary benchmarks.
* Contact SGV Geodesy for additional support, if required.
* At the completion of project construction, additional permanent marks may be required to be installed to ensure suitable coverage across the project area (as per Section 5.2) for future surveying and spatial applications.

### Register permanent marks

Permanent mark information **must** be submitted in SMES as per Regulations 6 and 7 of the Survey Co-ordination Regulations 2014

* Survey control mark information to be recorded in accordance with Section 4 of the ICSM SP1 [Guideline for Installation and Documentation of Survey Control Marks v2.2](https://www.icsm.gov.au/sites/default/files/2020-12/Guideline-for-Installation-and-Documentation-of-Survey-Control-Marks_v2.2.pdf).
* New permanent mark numbers **must** be reserved in SMES and assigned to each permanent mark according to the Parish they are located in.
* Permanent mark sketch plans **must** be prepared for permanent marks using the template shown in Schedule 2 of the Survey Co-ordination Regulations 2014.
* Permanent mark information **must** be registered in SMES within **one month** of establishing a permanent mark or finding an unregistered permanent mark. Information includes:
  + Sketch plans, photos, coordinates, height, etc.
* Surveyors are also encouraged to prepare and register in SMES supplementary sketch plans for permanent marks when the existing sketch is no longer consistent with the situation in the local area.
* Project survey control marks may be withheld if not appropriate for inclusion in SMES – e.g. low quality monumentation, survey control marks in exclusion zones (rail corridors), project specific monitoring survey control marks.

# Control survey

Control surveys are to be performed in accordance with the ICSM SP1 Standard for the Australian Survey Control Network v2.2 and associated guidelines to achieve survey control uncertainty requirements of the project.

## GNSS control survey

Static GNSS control surveys to be performed in accordance with ICSM SP1 [Guideline for Control Surveys by GNSS v2.2](https://www.icsm.gov.au/publications/guideline-control-surveys-gnss-v22). This details static GNSS survey equipment, observation techniques and processing strategies to be employed to achieve survey uncertainty:

Table 6: Static GNSS survey example achievable survey uncertainty

| Static GNSS survey - example achievable survey uncertainty | |
| --- | --- |
| < 15 mm (Horizontal)  < 20 mm (Ellipsoidal height) | < 30 mm (Horizontal)  < 50 mm (Ellipsoidal Height) |

* When using GNSS to determine AHD height, static GNSS observations **must** be made to at least two VLN marks to verify GNSS survey observations and datum connection.

## Conventional traverse survey

Conventional traverse surveys to be performed in accordance with ICSM SP1 [Guideline for Conventional Traverse Surveys v2.2](https://www.icsm.gov.au/publications/guideline-conventional-traverse-surveys-v22). This outlines conventional traverse equipment and survey procedures to achieve survey uncertainty:

Table 7: Conventional traverse survey example achievable survey uncertainty

| Conventional traverse survey- example achievable survey uncertainty | | |
| --- | --- | --- |
| < 2 mm | < 10 mm | < 30 mm |

* Direct traversing connection to at least three Victorian SCN marks or marks established using static GNSS survey techniques required to verify datum connection and support integration into the Victorian SCN.

## Differential levelling survey

Differential levelling to be performed in accordance with ICSM SP1 [Guideline for Control Surveys by Differential Levelling v2.2](https://www.icsm.gov.au/publications/guideline-control-surveys-differential-levelling-v22). This details differential levelling equipment and survey procedures to achieve maximum allowable misclosure:

Table 8: Differential levelling survey example achievable maximum allowable misclosure

| Differential levelling survey - example achievable maximum allowable misclosure | | |
| --- | --- | --- |
| < 2 mm \* √K (km) | < 6 mm \* √K (km) | < 12 mm \* √K (km) |

* Direct levelling connection **must** be made to at least two VLN marks to verify AHD connection and support integration into the VLN.
* Where the difference between the direct levelling and VLN mark SMES published AHD heights exceeds a 12mm \* √K (km) misclosure, direct levelling connection **must** be made to additional VLN marks to verify the AHD connection and determine the sources of the discrepancy.
* Surveyors are required to advise SGV Geodesy of discrepancies in the SMES published AHD heights. Notification can be by email or included in support information accompanying the submission of control survey measurement data to SGV Geodesy.

## Surveying data adjustment and evaluation

Control survey data to be adjusted and evaluated in accordance with ICSM SP1 Guideline for Adjustment and Evaluation of Survey Control v2.2

* Horizontal (MGA2020) coordinates to be derived from a least-squares adjustment of the project survey control mark network constrained to the existing SCN permanent marks and nearby GNSS ground stations (if connected in GNSS survey).
* Vertical AHD heights to be derived from a two-way levelling survey reduction or least squares adjustment of levelling observations constrained to VLN permanent marks

# Control survey information

Control survey measurement data and support information **must** be submitted to SGV Geodesy for inclusion in the Victorian SCN and VLN.

## GNSS control survey

GNSS control survey measurement data and support information to be submitted include:

* Raw GNSS observation data in common proprietary binary format or RINEX format.
* Completed [booking sheet](https://www.land.vic.gov.au/__data/assets/word_doc/0022/541561/DELWP-GNSS-Booking-Sheet-Template_2021.docx) including key fields:
  + PM name and/or nine-figure number
  + Antenna and receiver type
  + Antenna height and height measurement method
  + Start and end times
  + File naming details associated to each measurement
* Additional information on the [submission of GNSS data](https://www.land.vic.gov.au/__data/assets/word_doc/0015/512331/GNSS-Submission-Fact-Sheet.docx) to SGV Geodesy.

## Conventional traverse survey

Conventional traverse control survey measurements observed with a total station and support information to be submitted include:

* Raw, unreduced total station observations in structured digital survey file format, such as .gsi or .fld.
* Measurement information to support three-dimensional adjustment of data, featuring:
  + Unreduced horizontal and vertical angle observations
  + Slope distances preferred over horizontal ground distance
  + Instrument and target heights recorded
  + All multiple sets of FL/FR and distance observations
  + Identifiable PM names/nine-figure numbers
  + Blunders removed or identified in support documentation
  + Observations predominantly recorded directly between PMs, minimising inclusion of TBMs where practical.

## Differential levelling survey

Differential levelling control survey measurement and support information to be submitted include:

* Raw, unreduced levelling observations in structured digital survey file format, such as .gsi and .fld.
* Measurement information to feature:
  + Unreduced back sight and fore sight observations
  + Identifiable PM names/nine-figure numbers
  + Blunders removed or identified in support documentation.

## Support documentation

Details of survey equipment, techniques and other information should be supplied to support the reduction and adjustment of control survey measurements. This may include:

* Booking sheets and field notes
* Summary of survey equipment and any calibration details
* Summary of permanent marks that feature in the control survey
* Summary of data files
* Any other relevant information.

1. Sample Contract Specification

This sample contract specification is provided as a guide. Survey uncertainty and positional uncertainty for horizontal coordinates and height are example only and should be revised to suit project requirements.

Survey control mark infrastructure and information is required to be established and surveyed in accordance with the Victorian Survey Control Requirements (2022). This includes:

* Establishment of a project survey control mark network that meets project requirements for monumentation and distribution in terms of survey control mark spacing and number of permanent marks.
* Control surveys performed to achieve project survey control uncertainty requirements.

| Project requirements | Survey uncertainty | Positional uncertainty |
| --- | --- | --- |
| Horizontal coordinates | < 10 mm | < 20 mm |
| Height | < 10 mm | < 20 mm |

* Control survey report (optional).
* Permanent mark information **must** be registered in the Survey Marks Enquiry Service (SMES).
* Control survey measurements **must** be submitted to SGV Geodesy for inclusion in the Victorian Survey Control Network and/or Victorian Levelling Network.