



**mainroads**  
WESTERN AUSTRALIA

Asset and Geospatial Information Branch  
Survey and Mapping Section

# Road Reference Marks

## 67/08/36

# Contents

<b>1</b>	<b>PURPOSE</b> .....	<b>4</b>
<b>2</b>	<b>SCOPE</b> .....	<b>4</b>
<b>3</b>	<b>DEFINITIONS</b> .....	<b>4</b>
<b>4</b>	<b>REFERENCES AND RELATED DOCUMENTS</b> .....	<b>4</b>
<b>5</b>	<b>ENTRY ONTO LAND</b> .....	<b>5</b>
<b>6</b>	<b>ENVIRONMENTAL IMPACT</b> .....	<b>5</b>
<b>7</b>	<b>ROAD REFERENCE MARKS</b> .....	<b>5</b>
7.1	GENERAL .....	5
7.2	PLACEMENT OF MARKS .....	6
7.3	CONSTRUCTION OF MARKS .....	6
<b>8</b>	<b>RRM POINT PRECISION</b> .....	<b>7</b>
8.1	HORIZONTAL PRECISION .....	7
	8.1.1 RTK USE FOR OBSERVATIONS-NOW NOT PERMITTED .....	7
	8.1.2 AREAS REMOTE FROM EXISTING STATE SSMS AND OR BENCHMARKS .....	7
8.2	VERTICAL PRECISION .....	7
	8.2.1 SECTION TOLERANCES .....	7
	8.2.2 TRAVERSE TOLERANCE .....	8
8.3	ADJUSTMENT .....	8
<b>9</b>	<b>RRM NUMBER ALLOCATION</b> .....	<b>8</b>
<b>10</b>	<b>DATA LODGEMENT</b> .....	<b>8</b>
<b>11</b>	<b>APPENDICES</b> .....	<b>9</b>
	APPENDIX A: BRASS PLAQUE ROAD REFERENCE MARK URBAN AND RURAL TOWNSITE AREAS .....	10
	APPENDIX B: ROAD REFERENCE MARK FOR STABLE SOIL. RURAL AREAS ONLY ....	11
	APPENDIX C: ROAD REFERENCE MARK FOR UNSTABLE SOIL – WHERE CLAY, BLACKSOIL, “CRAB-HOLES” EXIST. RURAL AREAS ONLY .....	12
	APPENDIX D: ROAD REFERENCE MARK PERMANENT MACHINE CONTROL CONSTRUCTION PILLAR .....	13
	APPENDIX E: ROAD REFERENCE MARK CONSTRUCTION PILLAR TEMPORARY .....	14
	APPENDIX F: ROAD REFERENCE MARK SUMMARY .....	15

# Document Control

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## Amendments

Revision Number	Revision Date	Description of Key Changes	Section / Page No.
1.0	29 <sup>th</sup> November 2006	Original published	N/A
1.1	13 <sup>th</sup> January 2014	Minor amendments	N/A
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1.3	12 <sup>th</sup> February 2015	Minor amendments	N/A
1.4	15 <sup>th</sup> March 2017	Minor amendments / Format change	All
1.5	5 <sup>th</sup> July 2018	Remove RTK option from survey method; RMs. Protection of RRM for Construction.	7.3;8.1.1
1.5	5 <sup>th</sup> July 2018	Remote area methods	8.1.2

## 1 PURPOSE

The purpose of this Standard is to detail Main Roads requirements for Road Reference Marks.

## 2 SCOPE

This Standard shall apply for all Road Reference Marks established for Main Roads.

Advice and further information can be obtained by contacting the Senior Geodetic Surveyor.

## 3 DEFINITIONS

The following terms used in this procedure have the specific meanings indicated:

Term	Definition
MGA	Map Grid Australia
GDA	Geodetic Datum Australia
AHD	Australian Height Datum
GPS	Global Positioning System
RTK	Real Time Kinematic
DGPS	Differential Global Positioning System
ICSM	Intergovernmental Advisory Committee on Surveying & Mapping
SSM	Standard Survey Mark
RM	Reference Mark
RRM	Road Reference Mark
VRS	Virtual Reference Station
CORS	Continuously Operating Reference Station
MCP	Minor Control Point
GNSS	Global Navigation Satellite Systems

## 4 REFERENCES AND RELATED DOCUMENTS

Document Number	Description
	ICSM – Standard for the Australian Survey Control Network (SP1 ver. 2.0)
	GDA Technical Manual, Version 2.2
<b>67-08-100</b>	Survey and Mapping Guideline- Metadata Requirements
<b>67-08-38</b>	Differential Levelling Standard
<b>D12 # 434757</b>	Survey Control for Construction Guideline

## 5 ENTRY ONTO LAND

It is the Consultant's responsibility to seek and obtain permission from landowners, occupiers or management authorities before entering any property to undertake any survey and mapping work. Property includes Crown land which may consist of Reserves, National Parks or State Forests. Survey and mapping work may include, but is not limited to, the investigation, capture, placement and coordination of survey control points, the placement and removal of survey control targets, the collection of digital terrain models and the undertaking of field audits.

The consultant shall maintain a written report of all contact made with landowners while working on the survey or mapping contract. Details of landowner contact are to be outlined in the metadata statement. Any queries made by land owners with respect to the project that are unable to be answered by the consultant are to be referred to the Main Roads project manager.

If access onto land is refused by the owners, the consultant will be required to immediately contact the Main Roads project manager to discuss the need for entry onto the land. If entry is required for the completion of the contract and there are no other alternatives, then Main Roads will arrange formal notification using delegated powers under the Land Administration Act. A formal notice of entry requires Main Roads to provide 7 days' notice to the owners. The process to arrange the formal notice of entry may take some time and the consultant must liaise with the Project Manager to ensure disruption to the contract schedule is minimised.

## 6 ENVIRONMENTAL IMPACT

All work is to be performed such that environmental impact is minimised. Any breach of environmental and heritage legislation during the execution of works is the sole responsibility of the consultant.

The consultant shall ensure any disturbances to the environment are kept to an absolute minimum. The consultant shall reinstate, clean-up and leave the site as close to its pre-disturbed condition as possible on completion of any work or investigation.

New tracks shall not be formed, existing tracks altered, fencing cut, clearing carried out, or damage or disturbance made of any kind unless approved by the Main Roads project manager. The consultant shall be responsible for the cost of reinstating any damage to property or the environment resulting from their work.

## 7 ROAD REFERENCE MARKS

### 7.1 GENERAL

RRMs are established and then coordinated and levelled on most project sites to create the control network to facilitate construction set out and subsequent audit. Radiations (distance and bearing) are then calculated for the project and set out occurs from these marks.

It is preferable, though not always possible; to place these marks after the clearing extents have been cleared/earth worked/set out.

It is critical that accuracy standards of the RRM's are maintained to ensure construction tolerances can be met. The relative uncertainty (RU) between adjoining RRM's should not exceed **0.006m**. For a definition of RU please refer to the SP1 Standard, at section 4.

## 7.2 PLACEMENT OF MARKS

Unless otherwise specified, RRM's shall be:

- **Located to ensure safety of the surveyor and public.**
- Situated at a maximum of 400 metres apart.
- A minimum of 15 metres and preferably 25 metres from the design or existing centreline or at other locations considered safe during construction. EG. Outside the clearing line.
- Intervisible to at least one adjacent RRM or SSM.
- Located adjacent to all intersections so that it is possible to define intersection details and be able to see a minimum of 100 metres along the intersecting road. For a large intersection a pair of marks may be required.
- **Located away from underground services in the area. Due to the depth of the star picket there is a real danger that some underground cables may be damaged. Such damage will be the responsibility of the Surveyors placing the RRM's**

## 7.3 CONSTRUCTION OF MARKS

Construction as per Appendix A (Urban) must be adhered to for all RRM's installed in the metropolitan and rural townsite areas. RRM's may be installed under a reticulation type cover (plastic or concrete) where this will improve pedestrian safety and the amenity of the area it is located in.

Construction as per Appendix B and C applies to rural areas outside townsite limits.

Construction as per Appendix D and E may be considered for specific job needs.

Where an RRM is set in concrete, it must have its allocated number stamped on an aluminium plate set flush in the concrete to aid in its identification.

It is preferable in areas of soft sand, that each RRM be referenced by two spikes set in concrete. In small projects where only one to four RRM's are placed it is a requirement that at least one RRM be referenced.

It is essential to provide a bearing to each Reference Mark placed for future re-location and use in verification of the RRM. These can be magnetic or Grid bearings and labelled as such on the summary.

Where a long traverse of 5 or more RRM's is established, then the referencing can be reduced to every fourth mark but must include the first and last mark.

Existing Landgate Benchmarks or SSM's may be used as RRM's if suitable and safe to do so. Their coordinates may be upgraded or adopted as appropriate to the survey and their position or height checked from any of their reference marks found.

Witness plates are an important way of visually locating and protecting RRM's and their use is recommended for most situations. A stamped witness plate (RRM number and distance to mark) should be attached to a star picket then placed a suitable distance from the RRM (0 to 1 metre) and on the road side, **only if its placement will not compromise the safety of the Surveyor or the public. Other options for a pedestrian area would be to nail the plate flush into the concrete surround of the RRM or place it on nearby poles or wire fences etc.**

Brass plaques and witness plates may be obtained from the Main Roads Senior Geodetic Surveyor (08 9323 4152). Email: ray.watson@mainroads.wa.gov.au

Please refer to the Survey Control Guideline for more specific placement suggestions and for the **Protection of RRM's** which may be affected by Construction.

See the link below.

[https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/Survey/GeodeticSurveyingGuidelines/Pages/Survey\\_Control\\_for\\_Construction.aspx](https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/Survey/GeodeticSurveyingGuidelines/Pages/Survey_Control_for_Construction.aspx)

## **8 RRM POINT PRECISION**

### **8.1 HORIZONTAL PRECISION**

New RRMS are to be established by closed survey network or traverse from a minimum of two and preferably more existing registered RRMs and/or Landgate SSMS of suitable positional uncertainty (PU) and Horizontal accuracy.

In Metropolitan or Townsite areas, ideally only Landgate SSMS of 20ppm horizontal accuracy or less are to be used for RRM networks. In Rural areas where SSM control may be sparse, it would be suitable to use those marks with 30ppm stated accuracy or less.

The horizontal accuracy of any existing RRMs used in the new network must be verified in the network least squares adjustment, prior to adoption. Thus in the initial adjustment, with just the SSMS fixed (if possible), these RRMs should be “floated” to see if their existing coordinates can be adopted. In many areas of the State the existing RRMs have values based upon SSMS which may have been adjusted by Landgate since initial placement. Thus where existing RRMs are used it may be wise to re-observe them fully if they are 5 years old or more.

#### **8.1.1 RTK USE FOR OBSERVATIONS-NOW NOT PERMITTED**

Static GNSS baselines or total station measurements are preferred for new mark placement. Previous use of RTK techniques to coordinate new RRMs has introduced some uncertainty into the positional accuracy in some cases as highlighted by Audit surveys and thus has been removed as an option for new control placement surveys.

#### **8.1.2 AREAS REMOTE FROM EXISTING STATE SSMS AND OR BENCHMARKS**

In some areas it will be necessary to bring coordinates and or height in from AUSPOS positioning with say 3 hours of GNSS data. In these cases, newly placed RRMs must be linked by conventional levelling (and ideally a traverse) but adopting one of the AUSPOS derived level (AHD) values. A least squares adjustment incorporating all data will reveal any inconsistencies. This method must be stated on the RRM summaries and in the field report and should be approved by the Senior Geodetic Surveyor prior to survey.

### **8.2 VERTICAL PRECISION**

#### **8.2.1 SECTION TOLERANCES**

All new RRMs shall be levelled with a two way traverse which must include a minimum of two existing spirit levelled control points or one Landgate Benchmark or existing RRM with validated reference marks.

The difference between the forward and backward levelling of any section or any combination of adjacent sections shall not exceed:

- $0.012\sqrt{K}$  metres where K is the distance in kilometres.
- The vertical accuracy for distances less than 1km shall be on a prorata basis relative to a 4 km tolerance (0.024 meters). For example the accuracy for a section 500 meters long shall be  $\pm 0.003$  metres or better.

### 8.2.2 TRAVERSE TOLERANCE

The misclose of a traverse between validated datum bench marks should not exceed  $0.012\sqrt{K}$  metres where K is the total distance of a traverse in kilometres. When this tolerance is achieved then the level traverse is to be adjusted to the datum values proportionally according to distance along the traverse. Refer to Appendix A in the Main Roads Differential Levelling Standard 67-08-38 for a worked example. Errors greater than  $0.012\sqrt{K}$  detected in the original Benchmark or SSM traverse are to be reported to the Senior Geodetic Surveyor.

Note that all levelling for RRM placements should now be carried out using calibrated Fibreglass (or Invar) staves to conform to Landgate Standards for data lodgement and for improved accuracy.

### 8.3 ADJUSTMENT

All networks or traverses shall be adjusted using a Least Squares adjustment.

## 9 RRM NUMBER ALLOCATION

RRMs are uniquely numbered according to the current Main Roads road number. Such RRM number allocations are to be obtained from the Senior Geodetic Surveyor. The application for numbers should include road number, road name, start and finish SLK where known, plus the road section name and the number of marks required. RRM numbers allocated but not used, may be re-allocated by Main Roads to another survey.

## 10 DATA LODGEMENT

For each project involving the placement of RRMs, the following information must be submitted to the Senior Geodetic Surveyor.

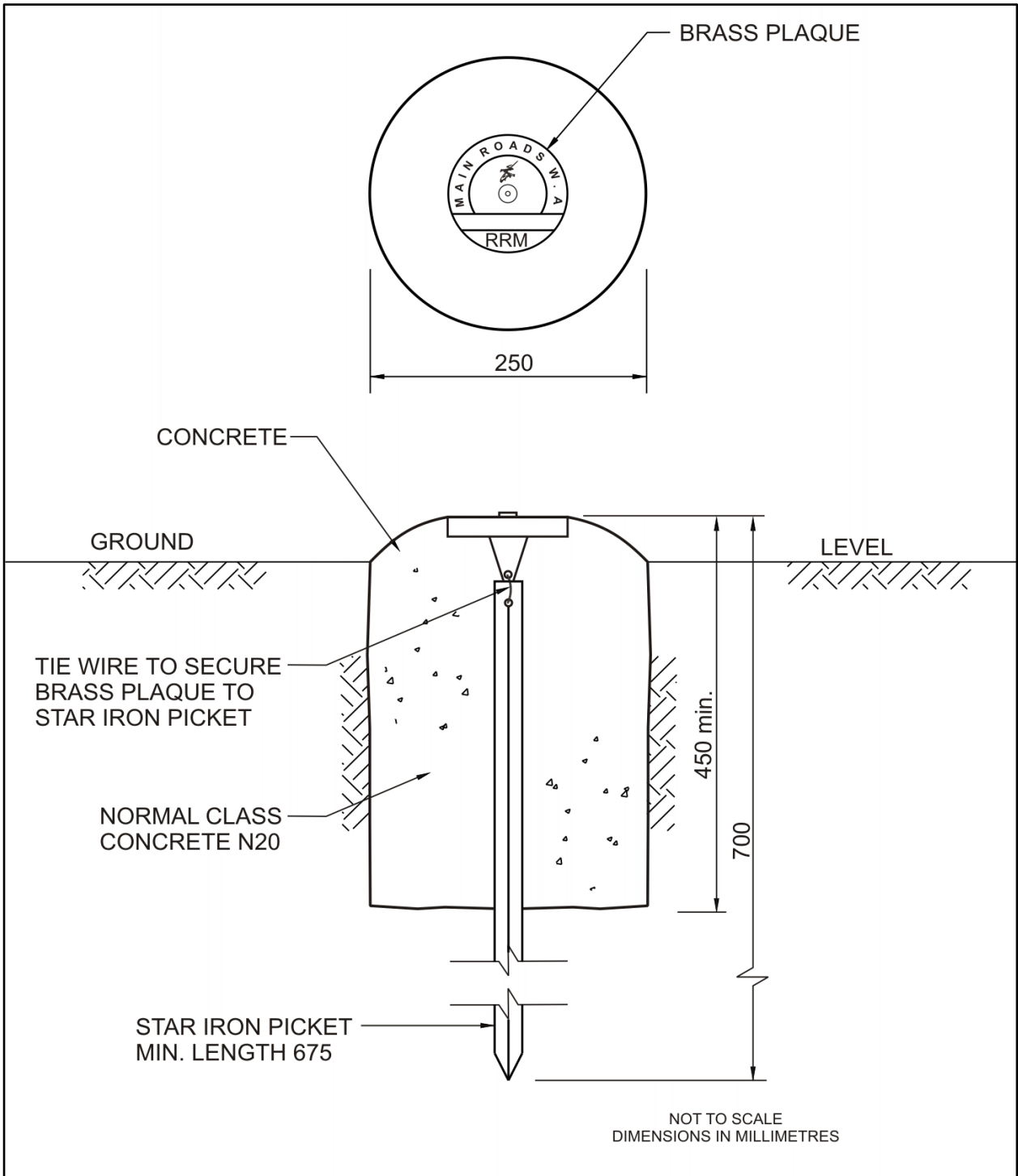
- a) A brief survey report (summary) with details of methodology used, and any other relevant information which expedites finalisation and registration of the new RRMs and clarifies any issues found.
- b) A sketch of the network observed shall be provided. This can be generated from the software package used for the least squares adjustment. It is very important for Main Roads to know what marks were used to provide coordination for the new RRMs.
- c) An RRM summary form (APPENDIX F) shall be completed for each RRM established, and lodged in JPEG format. All details on the RRM Summary form must be completed including MGA and Project Zone coordinates.
- d) An excel file showing: pt. #, E, N, RL, Zone, Datum for **all points** in the network and a brief header showing project information. State whether marks are new or existing.



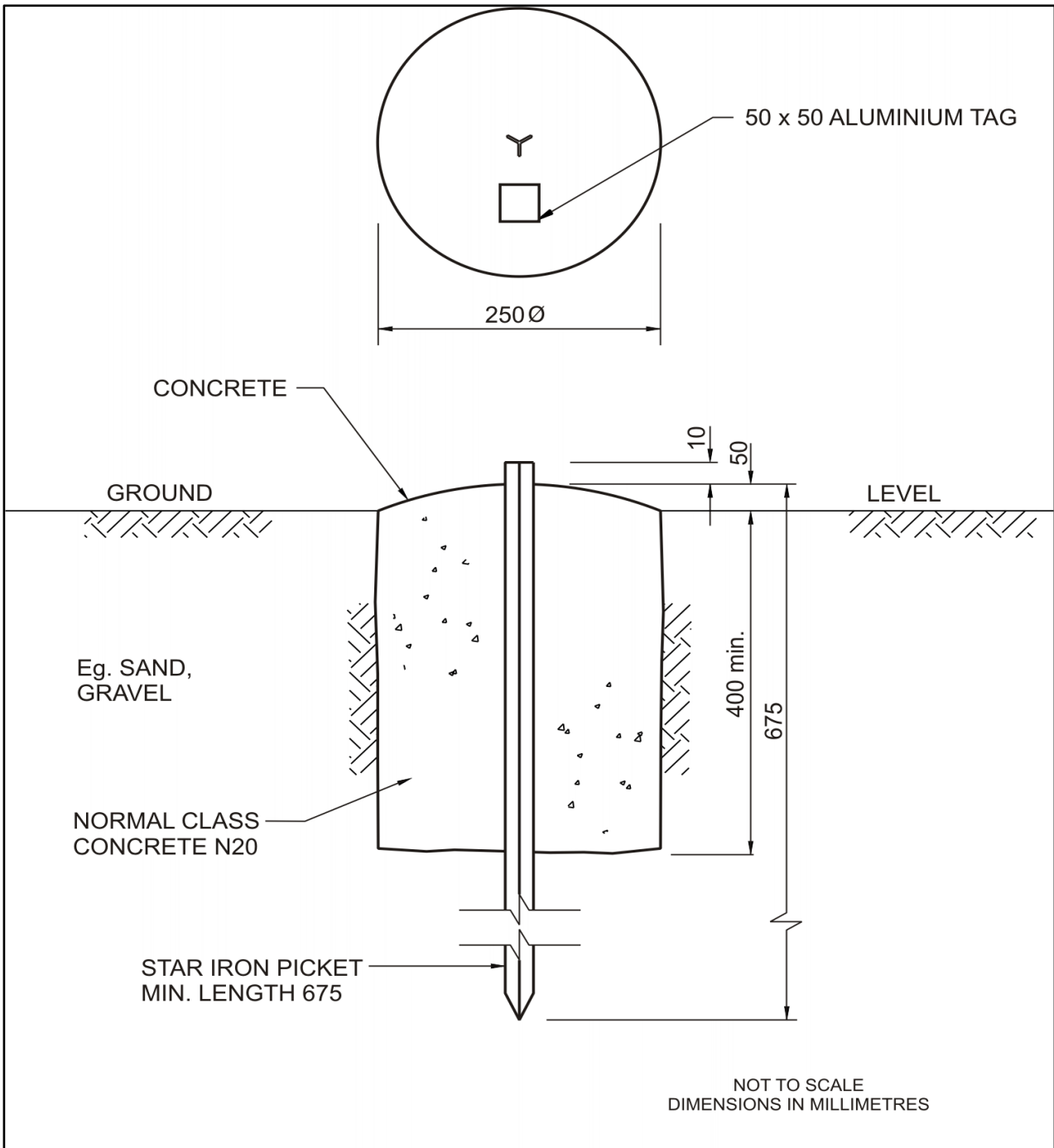
## 11 APPENDICES

Appendix	Title
<b>Appendix A</b>	Brass Plaque Road Reference Mark Urban and Rural Townsite Areas
<b>Appendix B</b>	Road Reference Mark for Stable Soil Rural Areas Only
<b>Appendix C</b>	Road Reference Mark for Unstable Soil – Where Clay, Blacksoil, “Crab-holes’ Exist. Rural Areas Only
<b>Appendix D</b>	Road Reference Mark Permanent Machine Control Construction Pillar
<b>Appendix E</b>	Road Reference Mark Construction Pillar Temporary
<b>Appendix F</b>	Road Reference Mark Summary

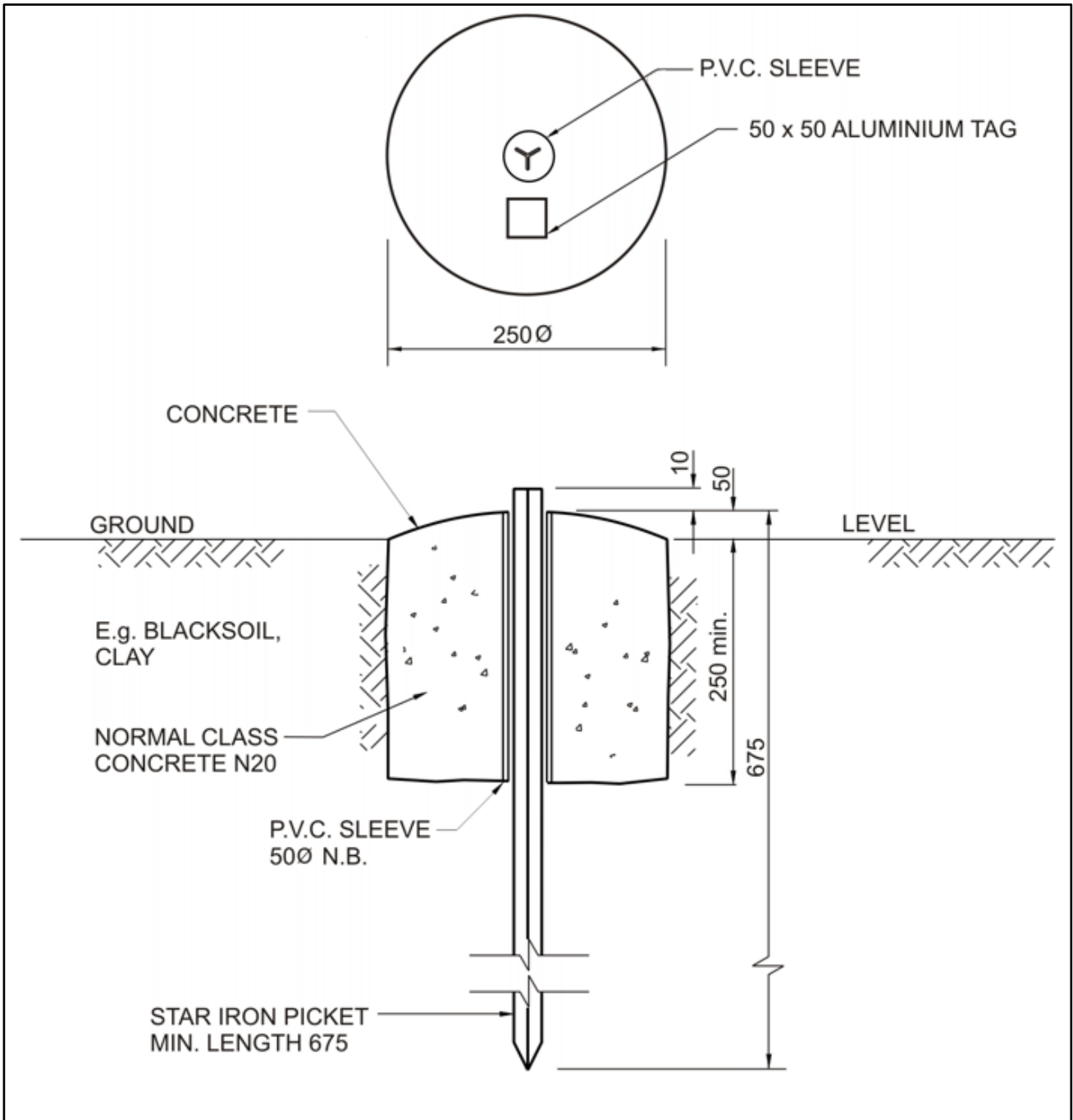
## APPENDIX A: BRASS PLAQUE ROAD REFERENCE MARK URBAN AND RURAL TOWNSITE AREAS



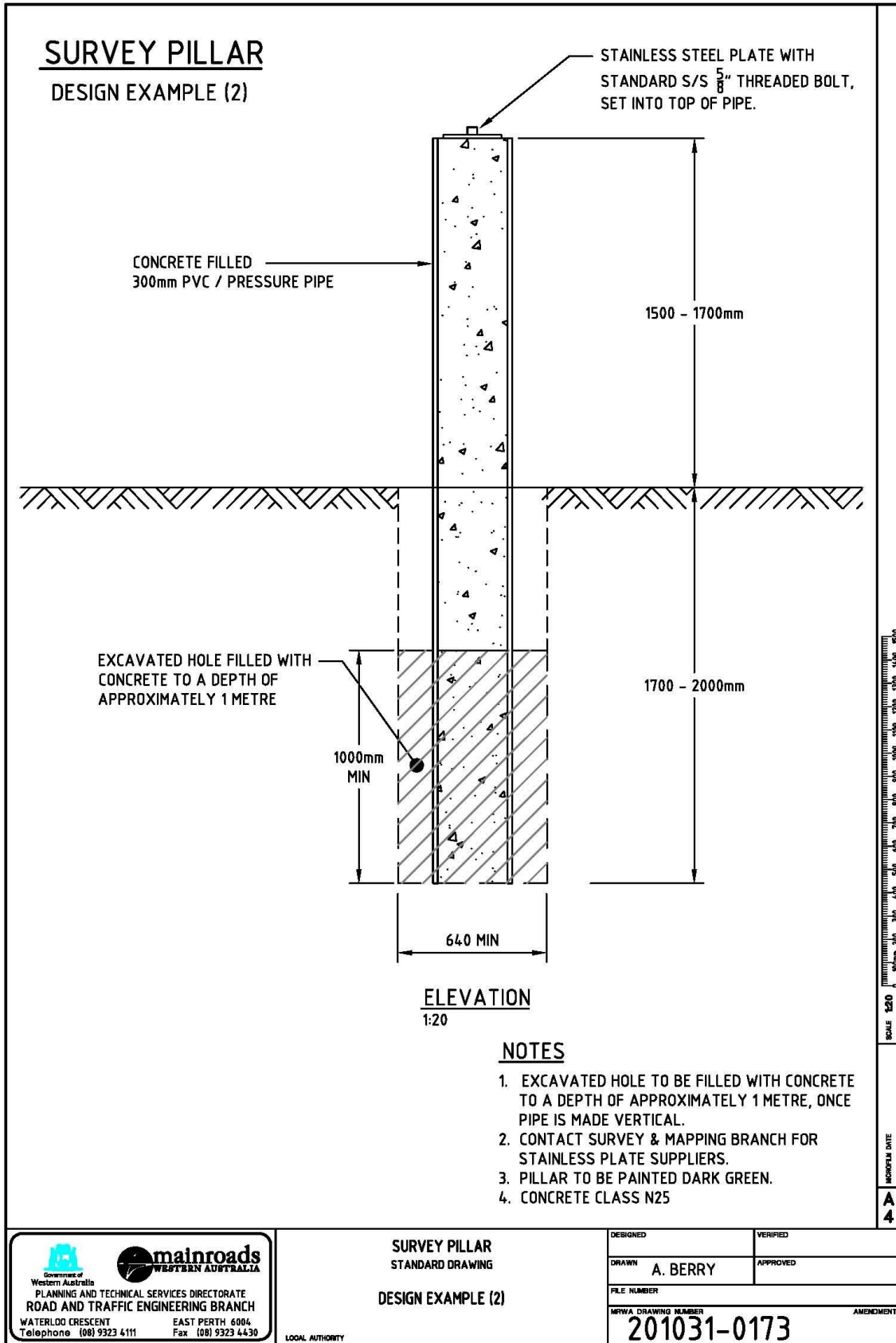
**APPENDIX B: ROAD REFERENCE MARK FOR STABLE SOIL. RURAL AREAS ONLY**



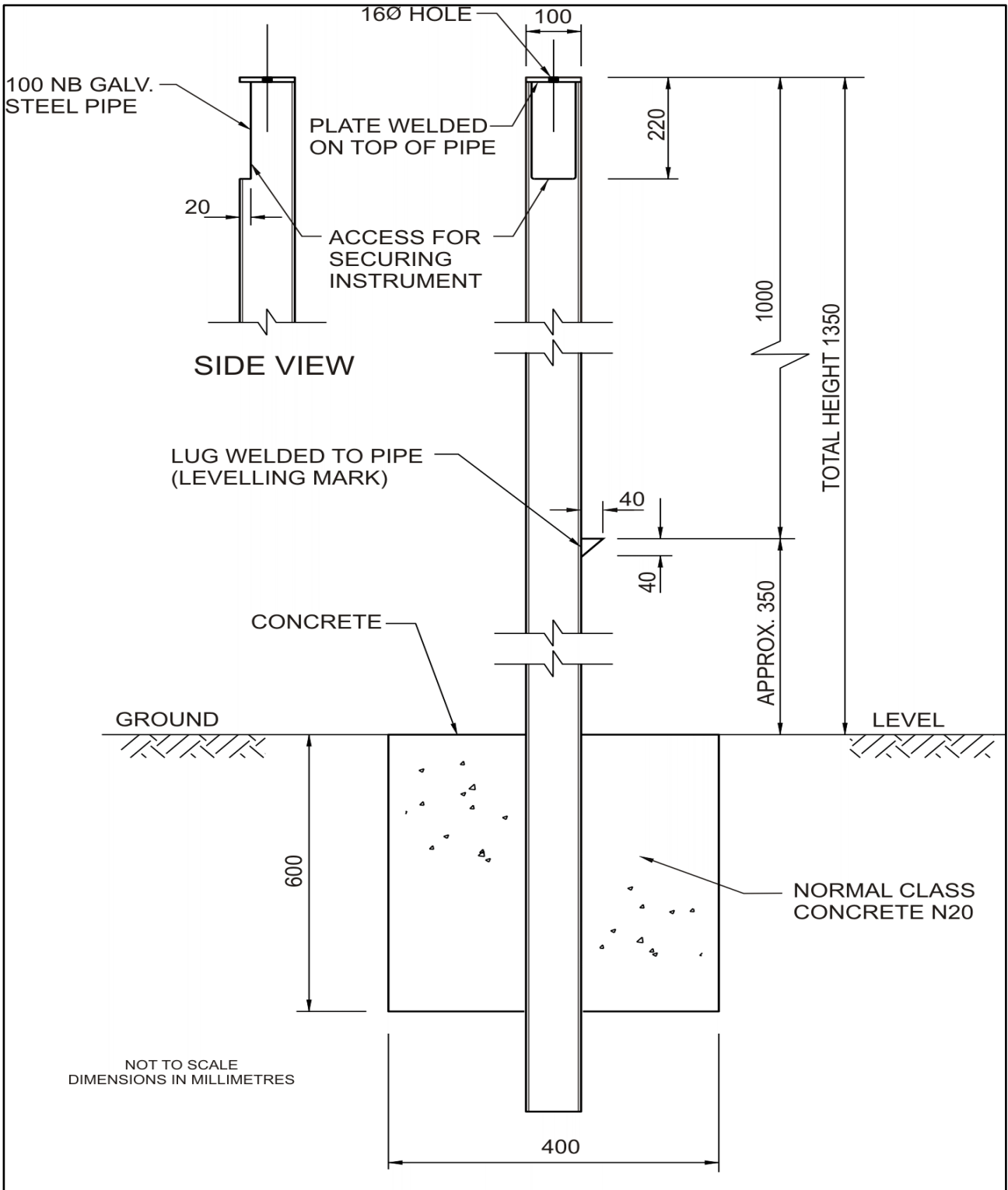
**APPENDIX C: ROAD REFERENCE MARK FOR UNSTABLE SOIL – WHERE CLAY, BLACKSOIL, “CRAB-HOLES” EXIST. RURAL AREAS ONLY**



## APPENDIX D: ROAD REFERENCE MARK PERMANENT MACHINE CONTROL CONSTRUCTION PILLAR



### APPENDIX E: ROAD REFERENCE MARK CONSTRUCTION PILLAR TEMPORARY



## APPENDIX F: ROAD REFERENCE MARK SUMMARY



ROAD REF MARK No.
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<b>ROAD NAME :</b>	<b>Road No.</b>
<b>SECTION :</b>	<b>SLKm :</b>
<b>REGION :</b>	<b>LOCAL AUTHORITY :</b>
<b>SURVEYOR :</b>	<b>DATE:</b>
<b>FIELD BOOK No :</b>	<b>LEVEL BOOK No :</b>

<b>MGA 94 ZONE :</b>	<b>EASTING :</b>	
<b>PROJECT GRID :</b>	<b>NORTHING :</b>	
<b>AHD HEIGHT (MARK) :</b>	<b>EASTING :</b>	
	<b>NORTHING :</b>	
	<b>(RM1) :</b>	<b>(RM2) :</b>
<b>OBSERVATION TYPE:</b>	<b>GNSS STATIC</b> <input type="checkbox"/>	<b>TOTAL STATION</b> <input type="checkbox"/>

Mark is a	<b>DESCRIPTION AND LOCATION DIAGRAM</b>