BUREAU OF
METEOROLOGY

OBSERVATION SPECIFICATION NO. 2013.1.

GUIDELINES FOR THE SITING AND EXPOSURE OF METEOROLOGICAL INSTRUMENTS AND OBSERVING FACILITIES.

JANUARY 1997

BUREAU OF METEOROLOGY

Department of the Environment, Sports and Territories.

OBSERVATION SPECIFICATION NO. 2013.1.

(Supersedes Observation Specification NO. 2013.)

GUIDELINES FOR THE SITING AND EXPOSURE OF METEOROLOGICAL INSTRUMENTS AND OBSERVING FACILITIES.

Issued: January 1997.

R.Canterford.
Superintendent Networks and Measurements.

Distribution:

All Regional Directors: 6 copies.
ADO, ADS, ADC.
STNM, STES, STIE, STRE, STAW, STCC, STAD, STSW, STPM.
SRDM, SROO, SRLR, SRPP, SRNF, SREM, SRUM, SRSI, SROG, SRDF, SRAV, SRPM.
LAB, RAD, BAPS
FOU: 15 Copies

GUIDELINES FOR THE EXPOSURE OF METEOROLOGICAL INSTRUMENTS AND OBSERVING FACILITIES.

Table of Contents.

TABLE OF CONTENTS

TABLE OF CONTENTS

1 Introduction

1.1 Purpose.

The purpose of this document is to provide guidance for the selection of sites for meteorological instruments and facilities which meet the minimum standards of exposure as stipulated by the Australian Bureau of Meteorology. These guidelines endeavour to take into consideration financial and practical limitations whilst preserving the scientific quality of the observations.

The meteorological facilities included in this specification are those which the Bureau of Meteorology must establish in order to fulfil its mandated responsibilities. These stations include aviation, synoptic, reference climate, special purpose and BAPMoN stations, and the supporting facilities for upper air observations programs.

The meteorological instruments in this specification include those surface based instruments which currently or in the future could provide data to the Bureau. These instruments range from upper air systems through the suite of conventional instruments (anemometers, thermometers and the like) to radar and to marine equipment. As new instruments and systems are developed with special siting and exposure requirements, it is intended to add additional sections to this document.

Meteorological instruments and observing facilities provide information with a range of applications to numerous activities in the community. Site selection will depend upon minimum exposure standards, cost of acquisition and implementation, and data requirements for that locality. Duplication of sites in the same locality for different purposes should be avoided if one site can satisfy the needs of all users of the data in terms of representativeness and spatial distribution.

1.2 Standards.

The siting and exposure of observing facilities and meteorological instruments, as outlined in this document, conforms to or exceeds the requirements stipulated by the World Meteorological Organisation (WMO), the International Civil Aviation Organisation (ICAO), the Civil Aviation Safety Authority (CASA) and the Standards Association of Australia (SAA). The bibliography at the end of this document specifies those references from the above authorities that form the basis of this document.

The siting and exposure criteria outlined in this document have been developed to ensure that measurements made from appropriately exposed instruments will be of an acceptable standard for scientific and research institutions, both within Australia and internationally.

Opting for sites which do not meet the criteria outlined in this document will reduce their scientific acceptability. It is inevitable that some localities for which observations are essential, may not have sites that fully conform to the criteria outlined in this document for a variety of reasons. Under these circumstances, a compromise must be reached when selecting the site, balancing scientific acceptability against practical and financial considerations.

When it is considered that an exception to these siting guidelines must be made, a statement detailing reasons for the exception should be prepared and endorsed by the Regional Director responsible for that installation. This statement should then be forwarded to STNM, who must approve the exception.

1.3 User requirements.

When selecting the site for a meteorological facility or instrument, the most important task is to identify and prioritise all the users' data requirements for that locality. The site selected should meet all of the key, high priority requirements. If no single site can be identified which does so, it would be advantageous to install additional equipment at an/other site(s) as funds permit to compensate for the deficiencies of the primary site.

If the station is to operate as a Meteorological Information Office (MIO), then public access to the station would be advantageous. However, the exposure requirements of the site should not be compromised solely to provide easy public access.

The WMO, during the Eleventh Session of the Commission for Instruments and Methods of Observation (CIMO-XI) established a comprehensive set of accuracy standards for meteorological measurements (see Attachment 2). The siting and exposure of meteorological instruments and facilities needs to be of a suitably high standard in order that these standards are met or bettered.

1.4 General siting considerations.

The selection of a site for meteorological installations is a complex process and a degree of judgement is normally required. Before a site for more complex meteorological measurements is finally accepted, all Regional and Head Office sections concerned with data quality and user requirements should be consulted and their approval gained. A preferred site and one or more alternative sites should be selected as the first step. Agreement between all concerned parties should be obtained prior to the referral of the proposed site(s) to Head Office. It is vital that the site selection process be correctly documented, with the exposure of the instrumentation to be installed at that site clearly identified. This documentation must be updated in time as the exposure of the instruments alters.

An assessment of the microscale meteorological influences of the area should take account of:

- the effects of topography (terrain, coastlines, large bodies of water);
- prevailing winds and directions from which significant weather is likely to approach;
- vegetation;
- current and future urban or industrial developments and infrastructure;
- the site's albedo and soil type.

Topographic maps, satellite imagery or aerial photography and climatological records should be consulted when preparing this assessment. The site selected should be representative of the mean conditions over the area of interest, be it an airport or a climatic region, unless it is intended that the instruments to be installed at that site are to monitor extreme or specific localised phenomena.

Sites chosen must not be:

- subject to flooding or inundation by storm surge;
- affected by a high water table;
- prone to subsidence;
- unduly susceptible to lightning strike; or
- vulnerable to wildfire.

Consideration should be given to the selection of sites where some form of pre-existing security is available (e.g. restricted public access if the site is not manned).

Should the site be in an area subject to accumulations of blown snow or sand, the design of the installation should take into account the weather conditions which normally create the accumulations so as to minimise them. The facility or instrument must still be able to operate effectively in the presence of accumulated sand or snow.

1.5 Cost considerations.

Consideration must be given to the cost of the following services, where relevant :

- power (including back-up and/or UPS); water and sewerage;
- telephone lines, fibre optic links, satellite links, radio or other communications;
- restrictions to, and licences for, the use of radio frequencies;
- extent of site and civil works required, including restrictions imposed in airfield locations and all cable trenching requirements;
- access roads;
- cost of the site and necessary buffer zone required to maintain the correct long term instrument exposure (includes purchase, lease and rental costs), bearing in mind the likely permanent nature of the installation, security and safety requirements of the site (e.g. RADAR).

1.6 Maintenance and access considerations.

All instruments and observing facilities require regular maintenance and calibration. All weather access roads are, therefore, a major consideration. Where observations must be made at a particular location, or continuous operation is not essential, access roads which are only likely to be impassable for short periods would be acceptable. If alternate sites are available that are suitable in other respects, the site with the easiest access from the maintenance base should be selected.

Redundant systems may be required for island sites. Island sites should be selected which have suitable landing areas for aircraft or helicopters, and/or fair weather mooring/landing areas for marine craft. The site itself must be well above the highest storm surge level that can be reasonably expected to occur at that location. In so far as it is possible, sites on islands should be selected that have some protection from wind driven sea spray.

The previously mentioned points not withstanding, the site should afford 24 hour per day access, 365 days of the year, without the need for undue or time consuming security clearance procedures. Should the equipment be required in a secure area, arrangements for access on demand need to be made.

1.7 Environmental considerations.

The site should afford some protection against environmentally caused corrosion, including from salt (sea and salt lake origin) and from chemical contamination (such as from an adjacent industrial area or major freeway).

Sites, including access areas, should be selected so as to minimise disturbance to areas with sensitive or competing land uses.

The facility must also be positioned so as to minimise its impact on the environment.

2 Facilities

2.1 Bureau Observing Offices at Airports

2.1.1 An observing office with its primary function being the provision of observations for services to the aviation industry needs to be sited so as to provide an unobstructed view of the weather conditions over the aerodrome and its immediate vicinity from the observer's normal working position. This view must be as free as possible from interference caused by airport lighting to allow night time observations to be taken. It should also be possible to secure from this position, or a position within about 30 metres, an unobstructed view of the approach and departure corridors for all runways. For more details, refer to ICAO 8896, ICAO Annex 3, WMO No. 731 and WMO No. 732.

2.1.2 The minimum requirement is to have information concerning current weather conditions over the full length of all runways. In locations where no single site is available that meets this condition, supplementary surveillance of the airport surrounds by a combination of additional automated observations and a remote controlled video camera may prove acceptable.

2.1.3 The observer requires easy access to meteorological instruments that need manual reading or daily maintenance. Easy access to the balloon release point is also required.

2.2 Co-operative Observing Stations and Automatic Weather Stations.

2.2.1 The primary function of a synoptic observing station, be it a manned observing station or an automatic weather station, is to provide observations which are representative of the prevailing weather throughout a region or locality. The general location is selected on the basis of proximity to existing stations, with consideration given to the need to monitor certain meteorological parameters at that location or general area. For example, a coastal or island site may be superior to a corresponding slightly inland site for synoptic purposes, as the wind measurements are more representative of the synoptic scale in a marine environment (for more details, refer to the section on anemometers). Wind and rain are typically the most difficult elements for representative measurements. For a coastal station, it is advantageous to select a site where oceanographic and tidal observations can also be made, although it is rare to find a single site suitable for all types of observations.

2.2.2 The station should not be sited on or close to steep slopes, ridges, cliffs or hollows. It is also important to avoid sites near large buildings or other obstructions.

2.3 Reference Climate Stations.

2.3.1 A Reference Climate Station (RCS) is a meteorological station with a climatic record suitable for monitoring long term trends in the climate of a region. The WMO (WCDP 1986) has identified the minimum RCS network requirement as 2 - 10 stations per 250,000 km^2, preferably with an existing climate record of at least 30 years. The Bureau is initially aiming to ensure that at least 1 station per 250,000 km^2 is designated as an RCS. The RCS should give an adequate representation of all the climatic zones of Australia. Island stations and stations in the Antarctic could also be designated as RCS.

2.3.2 There may be a need to relocate an existing RCS (the National Climate Centre holds a list of Bureau stations defined as RCS) or to install a new station with the long term objective of it becoming an RCS. The following points are mandatory if a station is to become or remain an RCS:

- The site must be permanent. Any relocation should be minor and to a site which is expected to possess the same climate as the original site. (It must be possible to perform parallel observations at the new and old sites for a minium period of one year to identify and quantify inevitable minor climatic differences.)

- As a guide, sites should be selected where it is expected that the population of nearby towns will not exceed 10,000 people in the foreseeable future. It is best to select a site close to an agricultural or forestry research station, or a state or national park or other protected area where the surroundings can be expected to remain relatively constant for an extended period. It is undesirable to select a site near where extensive re- or deforestation is expected, or a large dam/artificial lake is to be constructed.

- The station needs to have the highest quality and well sited instruments whose exposure will not be subject to change over a long period of time, with reliable access for maintenance and calibration visits through all seasons of the year. It is also advantageous to have trained observers on site, although automation of observations may be acceptable provided strict quality control procedures are adopted at these sites.

- The station must be suitable for the measurement of temperature (including maximum and minimum) and precipitation, with pressure and humidity measurements highly desirable.

2.3.3 In addition to the RCS, the Bureau of Meteorology has several other reference networks (covering rainfall, temperature and agrometeorological parameters). Every effort must be made to preserve the continuity and accuracy of the meteorological observations at these stations.

2.4 Special Purpose Stations.

2.4.1 These stations, which may be used for a variety of purposes, including pollution studies, research projects, fire weather support and so on, must be sited to fulfil their special purpose. The exposure requirements of the particular instruments to be installed at the special purpose station need to be observed. If possible, the special purpose station should also be sited so as to provide climatic and/or synoptic data.

2.5 BAPMoN Station.

2.5.1 The Bureau acknowledges the siting requirements for a global change BAPMoN station as described fully in WMO No. 491 "International Handbook for Measurement of Background Atmospheric Pollution. These requirements will not be repeated here. In practice, it is rare to find a site which fully complies with these requirements, so a compromise must be made when selecting the site for a BAPMON station. These stations are highly specialised and the site selection for a new station will need to be studied in considerable detail. However, the site selection process should be cognisant of the exposure requirements of individual instruments, as outlined in this document. It is also likely that the station would be suitable as a Reference Climate Station and a synoptic station.

2.6 Upper air facilities.

2.6.1 Hydrogen Generation and Balloon Filling Facilities.

2.6.1.1 Most new or relocated Bureau upper air stations will be fitted with a remote balloon launcher. Hydrogen generation and conventional balloon filling facilities, where retained, should be designed as an integral part of an observing station.

2.6.1.2 The orientation of the balloon filling room doors will be determined by the surface wind climatology at the station's location. Normally, the door openings will be aligned perpendicular to the prevailing 10 metre wind direction at the station, where only winds of 5 m/s or more are considered when deciding upon the prevailing wind direction.

2.6.1.3 No object shall be placed within 90 metres of each of the balloon launching doors at the meteorological office and, beyond that distance, any closer to the doors than a distance which is five times the height of the object (see Figure 2.6.1). Refer also to the discussion contained in the remote balloon launcher section.

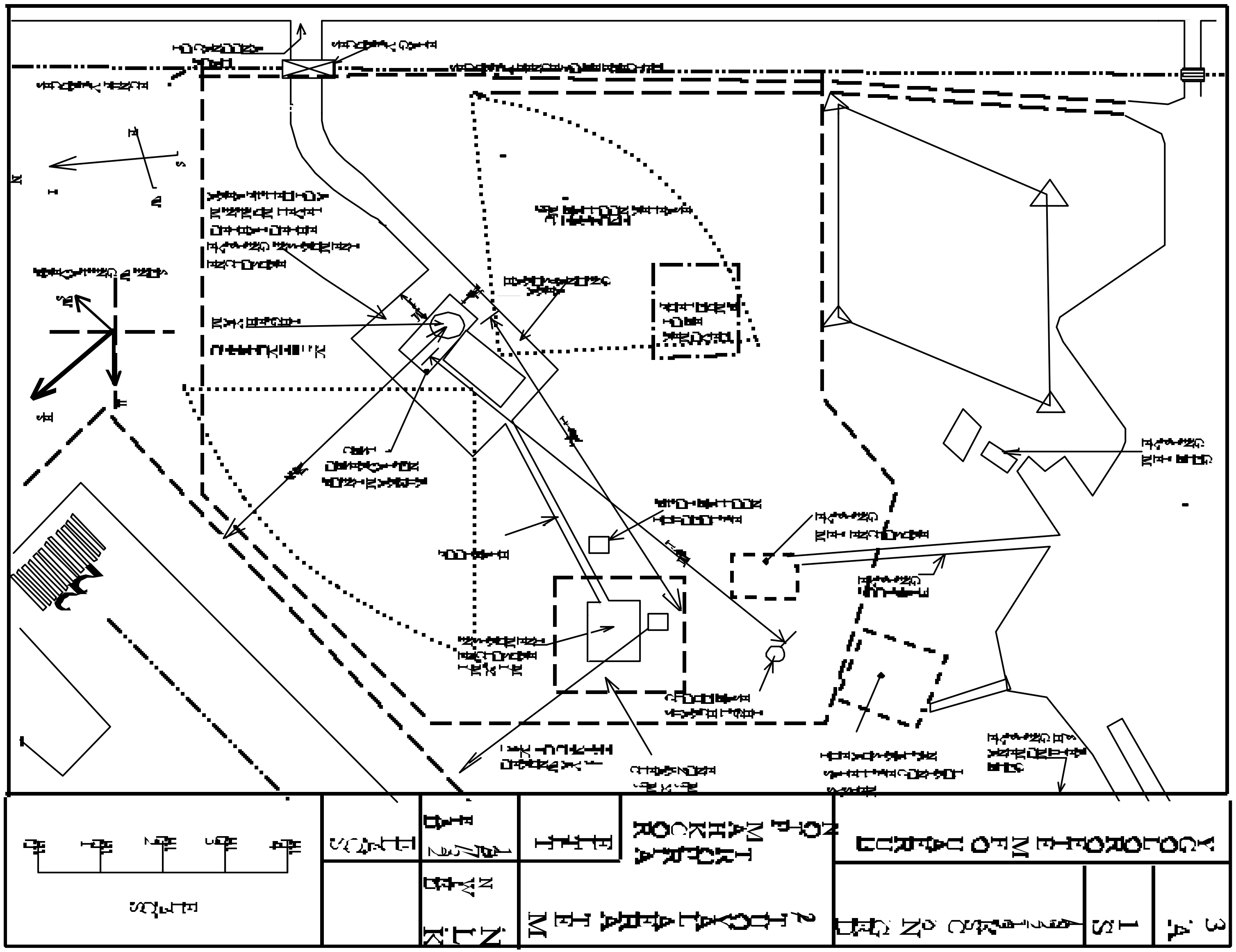


Figure 2.6.1 Typical Meteorological Observing Station illustrating clearance requirements for a balloon launching installation.

2.6.1.4 The location of the balloon release point should be clear of aircraft final approach and departure corridors (i.e. locations in line with runways should be avoided if at all possible).

2.6.2 Remote Balloon Launcher.

2.6.2.1 A Hydrogen Safety Area will extend for 20 metres in all directions from the launcher during the filling and launch procedure. At all other times a safety radius of 3 metres should be observed. Ideally, the remote balloon launcher should be surrounded by a clear buffer area extending a minimum of 40 metres in all directions to ensure an unobstructed launch path. However, application of this principle should be made in conjunction with the provisions of paragraphs 2.6.2.3 and 2.6.2.4 (below). Figures 2.6.2.1 and 2.6.2.2 provide examples of how a station with a remote balloon launcher could be configured. Note: all distances are taken from the RBL centre.

2.6.2.2 Based upon the assumption that the highest 10 metre wind speed a balloon will normally be launched in is 20 m/s, with turbulence reducing the ascent rate to a third of the normal rate, an acceptable launch success rate should be achieved provided no obstructions extend more than 4^{O} above the horizon. Note : all angular clearances measured from the top centre of the RBL.

2.6.2.3 Obstructions with elevations up to 8^{O} subtending an angle not exceeding 5^{O} of azimuth in total can be tolerated, provided they are located at a bearing from the launcher where climatological information indicates that the prevailing 10 metre wind will blow towards the obstruction on less than 5% of occasions for all wind speeds in excess of 5m/s. Particular attention should be given to the distribution of wind with a speed in excess of 10 m/s.

2.6.2.4 In the Antarctic and exposed south coastal areas where launches may be expected to be attempted in winds exceeding 20 m/s on a regular basis, the obstruction free angle should be lowered to 2^{O}, at least in the sectors towards which the prevailing wind blows.

2.6.2.5 The siting of the remote balloon launcher should be made in conjunction with the siting of the anemometer and the meteorological observatory building. When wind finding is to be performed by a wind find radar, it is important to ensure that the radar is as close as practicable to the RBL to ensure winds immediately following release are accurate, bearing in mind the previously mentioned clearance requirements.

2.6.2.6 When selecting a potential site for a RBL, consideration should be given to ensuring the mandatory clearance zones overlap with other mandatory clearance zones e.g. near runways and taxiways. Sites aligned with runways should also be avoided.

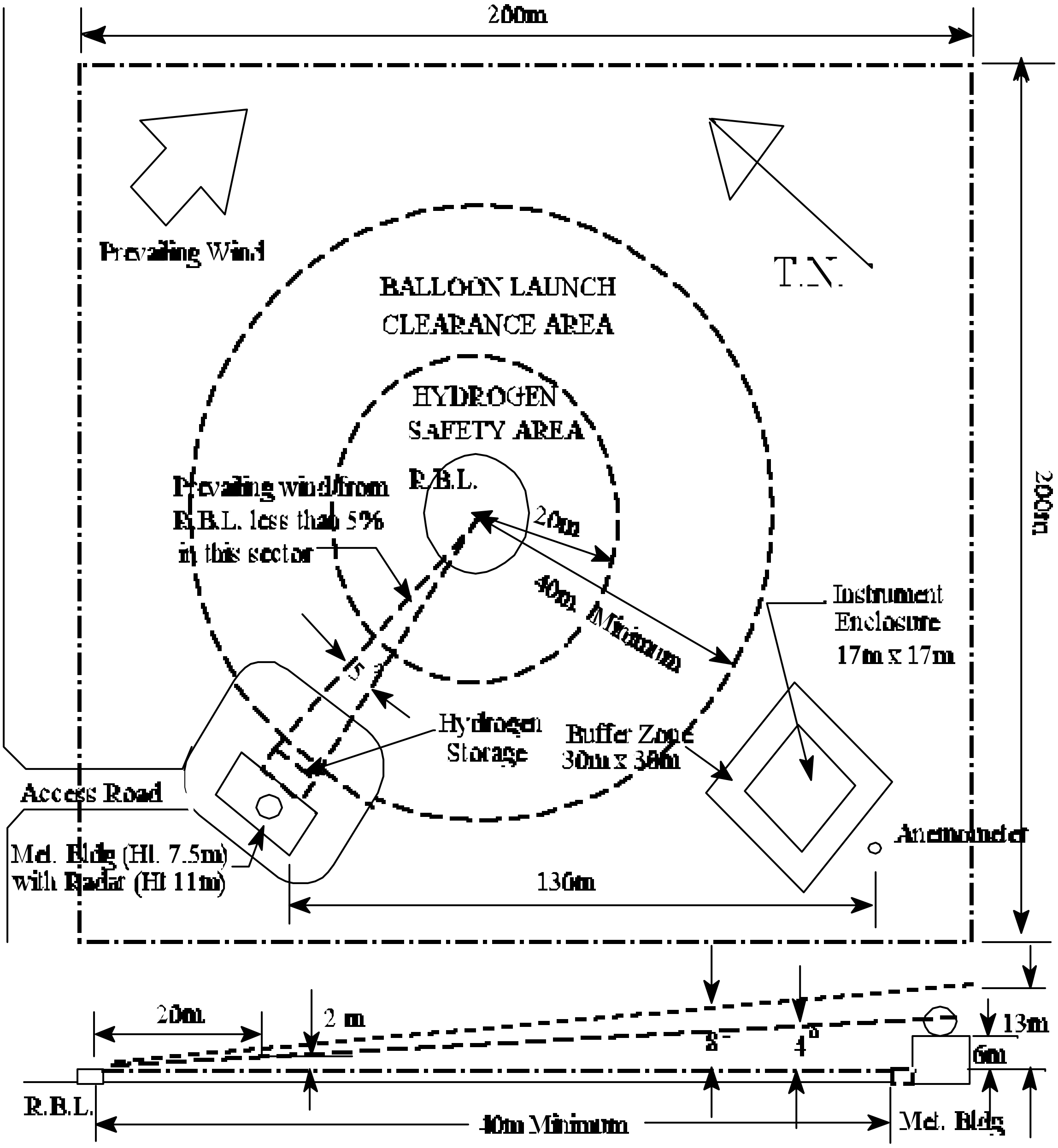


Figure 2.6.2.1 One configuration for a station with a remote balloon launcher.

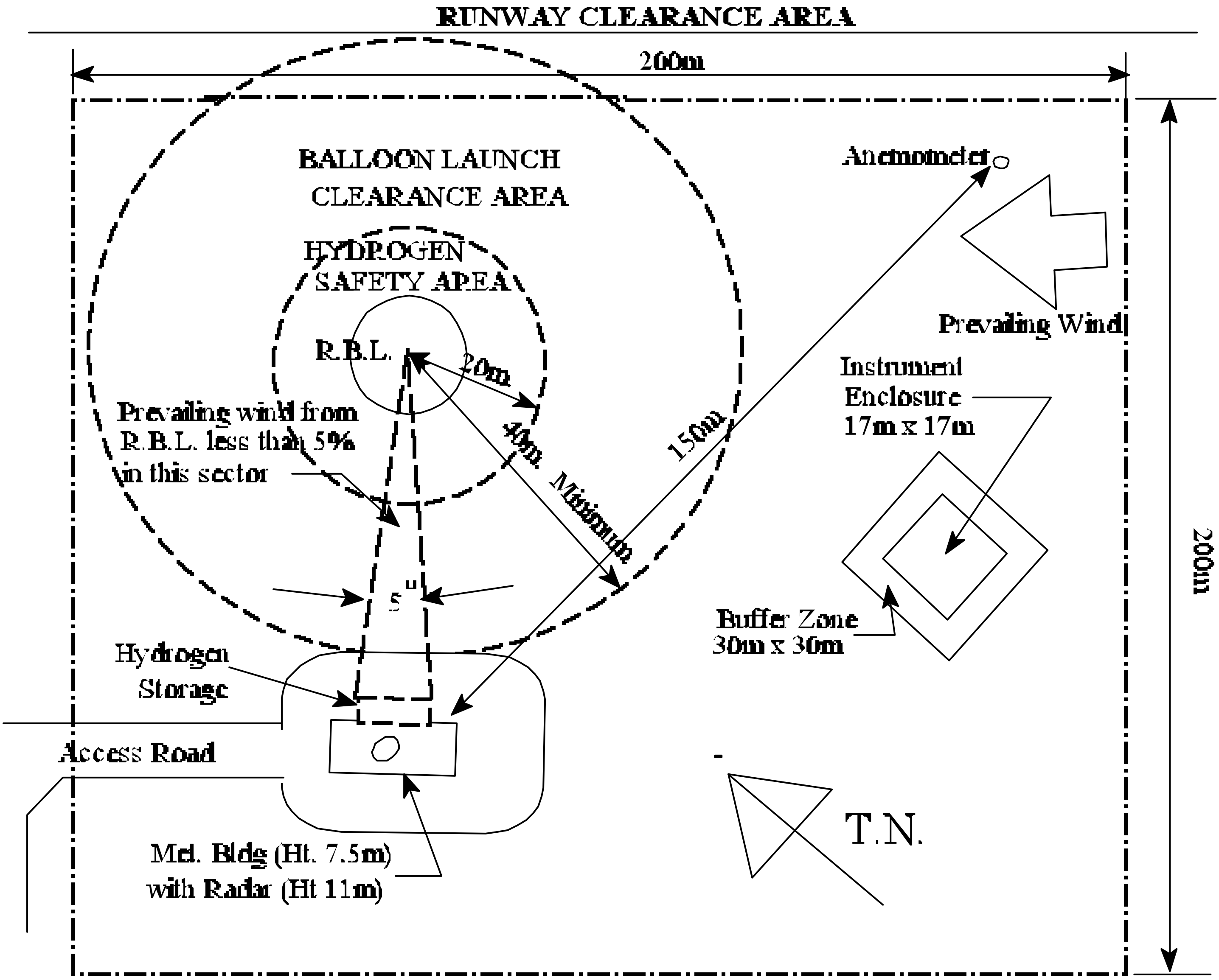


Figure 2.6.2.2 An alternative configuration for a station with a remote balloon launcher.

2.6.3 Theodolite Platform.

2.6.3.1 The theodolite platform is a solid, vertical pillar 1.54 metres high upon which the theodolite for visually tracking pilot balloons is installed.

2.6.3.2 From the position of the theodolite, the sky must be visible above an elevation of 4^{O} in all directions. Exceptions to this requirement can only be made where the climatological upper winds indicate a minimal loss of data will occur from an obstruction protruding above this elevation.

2.6.3.3 The theodolite position should be within 50 metres of the hydrogen generation shelter, but outside the 30 metre x 30 metre buffer area of the instrument enclosure and the mandatory balloon launch clearance corridors, and be easily accessible 24 hours of the day and in all weather conditions.

2.6.3.4 The theodolite position needs to be selected so that bright lights will not shine into the observer's eyes for night balloon flights.

2.6.3.5 If necessary to meet the above conditions, the theodolite may be mounted on an elevated platform up to 3 metres high.

3 Instruments.

3.1 Instrumentation at Airports

3.1.1 Instrumentation located at an airport for the purpose of providing data to support services of the aviation industry must be sited so that the measurements are representative of the airport as a whole, or of that part of an airport which the observation is meant to represent (WMO No. 731).

3.1.2 All instrumentation at an airport must be sited at locations which do not infringe the obstacle limitation surfaces for that particular airport. Future, as well as existing, limitation surfaces (eg for planned additional runways and taxiways) should be considered. However, a new obstacle located in the vicinity of an existing obstacle may be allowable if it fits the CASA shielding criteria. Figure 3.1.1 provides an indication of the restrictions imposed by the obstacle limitation surfaces, and Figure 3.1.2 provides illustrative examples of shielding effects. Full details are contained in ICAO Annex 14 and the CASA (CAA 1991).

3.1.3 For instrument enclosures at airports, the minimum distance between runways, taxiways, turning areas and aprons used by aircraft and the edge of the enclosure is as follows:

Turning areas and aprons	80m
Runways	60m
Taxiways.	30m

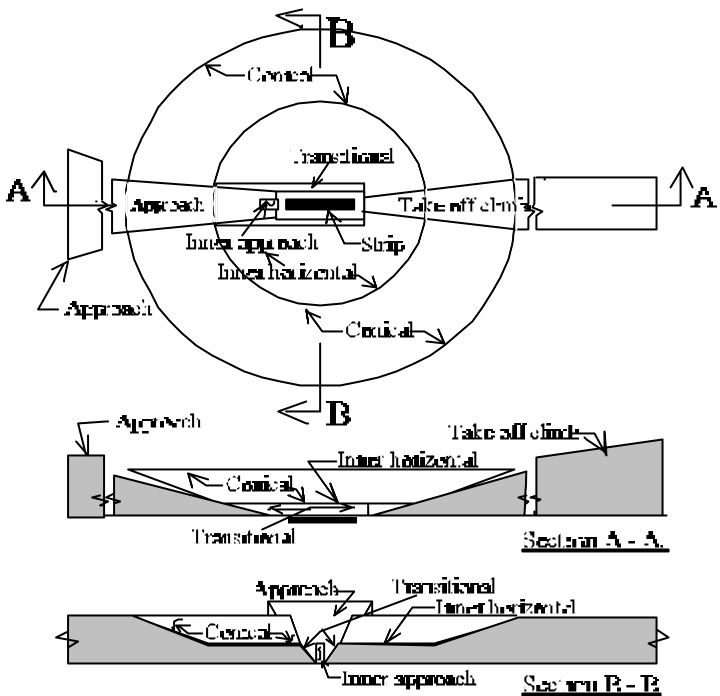


Figure 3.1.1 Obstacle Limitation Surfaces.

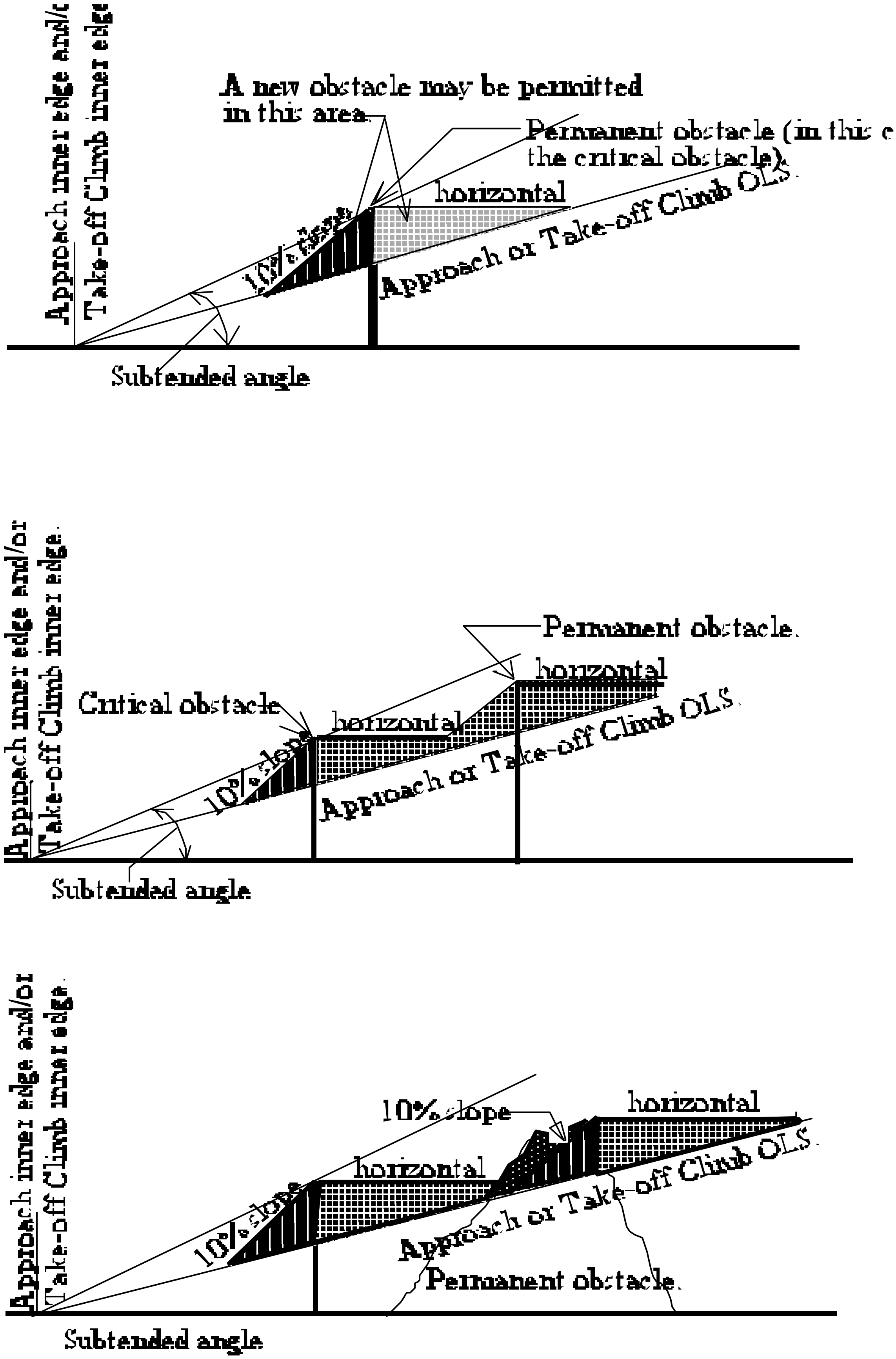


Figure 3.1.2 Shielding of obstacles penetrating the approach and take-off climb surfaces.

3.1.4 Code numbers are assigned to runways based upon their length and whether or not they are categorised as instrument or non-instrument landing. Each classification of runway has different clearance requirements, as indicated in Tables 3.1.4.1 and 3.1.4.2 for civilian runways. The **RAAF** should be contacted for military airport siting restrictions.

Table 3.1.4.1 - Approach Runways.

OLS Surfaces & Dimensions	Runway Classification									
	Non - instrument				Instrument					
					Non - precision			Precision		
								I		II & III
	Code No.				Code No.			Code No.		Code No.
	1	**2**	**3**	**4**	**1&2**	**3**	**4**	**1.2**	**3.4**	**3.4**
OUTER HORIZONTAL Height (m)							**150**		**150**	**150**
Radius (m)							**15000**		**15000**	**15000**
CONICAL Slope	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**
Height (m)	**35**	**55**	**75**	**100**	**60**	**75**	**100**	**60**	**105**	**105**
INNER HORIZONTAL Height (m)	**45**	**45**	**45**	**45**	**45**	**45**	**45**	**45**	**45**	
Radius (m)	**2000**	**2500**	**4000**	**4000**	**3500**	**4000**	**4000**	**3500**	**4000**	**4000**
APPROACH Length of inner edge(m)	**60**	**80**	**150***	**150**	**150**	**300**	**300**	**150**	**300**	**300**
Distance from threshold(m)	**30**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**
Divergence each side	**10%**	**10%**	**10%**	**10%**	**15%**	**15%**	**15%**	**15%**	**15%**	**15%**
First Section Length(m)	**1600**	**2500**	**3000**	**3000**	**2500**	**3000**	**3000**	**3000**	**3000**	**3000**
Slope	**5%**	**4%**	**3.33%**	**2.5%**	**3.33%**	**2%**	**2%**	**2.5%**	**2%**	**2%**
Second Section Length(m)	-	-	-	-	-	**3600**	**3600**	**12000**	**3600**	**3600**
Slope	-	-	-	-	-	**2.5%**	**2.5%**	**3%**	**2.5%**	**2.5%**
Horizontal Section Length(m)	-	-	-	-	-	**8400**	**8400**	-	**8400**	**8400**

Table 3.1.4.1 - Approach Runways.

OLS Surfaces & Dimensions	Runway Classification									
	Non - instrument				Instrument					
					Non - precision			Precision		
								I		II & III
	Code No.				Code No.			Code No.		Code No.
	1	**2**	**3**	**4**	**1&2**	**3**	**4**	**1.2**	**3.4**	**3.4**
Total Length(m)	**1600**	**2500**	**3000**	**3000**	**2500**	**15000**	**15000**	**15000**	**15000**	**15000**
INNER APPROACH Width(m)								**90**	**120**	**120**
Distance from threshold(m)								**60**	**60**	**60**
Length(m)								**900**	**900**	**900**
Slope								**2.5%**	**2%**	**2%**
TRANSITIONAL Slope	**20%**	**20%**	**14.3%**	**14.3%**	**20%**	**14.3%**	**14.3%**	**14.3%**	**14.3%**	**14.3%**
INNER TRANSITIONAL Slope								**40%**	**33.3%**	**33.3%**
BAULKED LANDING Length of inner edge(m)								**90**	**120**	**120**
Distance from threshold(m)								**#**	**1800+**	**1800**
Diverdence each side								**10%**	**10%**	**10%**
Slope								**4%**	**3.3%**	**3.3%**

All dimensions are measured horizontally unless otherwise specified.

\# Distance to end of strip.

* 90m where the width of the runway is 30m;

\+ or to the end of the strip.

Table 3.1.4.2 - Take - off runways.

Take - off climb surface ---- Dimension [a]	Take - off runways Code number.

Table 3.1.4.2 - Take - off runways.			
	1	**2**	**3 or 4**
Length of inner edge(m)	**60**	**80**	**180***
Minimum distance of inner edge from runway end[b] (m)	**30**	**60**	**60**
Rate of divergence (each side)	**10%**	**10%**	**12.5%**
Final width(m)	**380**	**580**	**1800[c]**
Overall length (m)	**1600**	**2500**	**15000**
Slope	**5%**	**4%**	**2%[d]**

a All dimensions are measured horizontally unless otherwise specified.

b The take-off climb starts from the end of the clearway if a clearway is provided.

c May be reduced to 1200m if the runway is used only by aircraft with take-off procedure which does not include changes of heading greater than 15 degrees for operations conducted in IMC or VMC by night.

d The operational characteristics of aircraft for which the runway is intended should be examined to see if it is desirable to reduce the slope to cater for critical operating conditions as specified in CAO 20.7. 1 B. If the specified slope is reduced, corresponding adjustment in the length of take-off climb surface is to be made so as to provide protection to a height of 300m. If no object reaches the 2% take-off climb surface, new objects should be dated to preserve the existing obstacle free surface or a surface down to a slope of 1.6%.

* Runways catering only for aeroplanes having an MTOW less than 22,700 kg which are operated in VMC by day only require a 90m inner edge length.

3.2 Automatic Weather Stations

3.2.1 Apart from the general siting requirements already mentioned (*See Attachment 3 for the Meteorological Automatic Weather Station Equipment Layout*.), the following specific requirements should be considered:

- The nature of the soil or rock must permit relatively inexpensive installation of the system and all its components, including any necessary protective fencing.
- The availability of electricity, including the need for uninterruptable power supplies, voltage stabilisers and line conditioners, or battery back-up.
- The availability of appropriate telecommunications facilities.
- Access to the site for calibration, maintenance and inspection purposes.

- Security of the site.

3.2.2 The anemometer of the AWS should meet the siting and exposure requirements mentioned in the anemometer section (section 3.5) of the specifications.

3.2.3 The installation requirements of the components of the automatic weather station vary with the type of AWS.

3.2.4 Bureau staffed stations.

3.2.4.1 The pressure sensor shall be that which is also used by the observer for the manual observations. The barometer shall be located in the Observation Office and accessable to the Observer,

3.2.4.2 The remaining sensors shall be in the instrument enclosure and adjacent to the manually read instruments with the AWS temperature sensors located in the same instrument shelter as the manually read thermometers. The anemometer or ceilometers and visibility meters/transmissometers if incorporated into the AWS, may be exceptions to these siting criteria. See relevant sections for details on their specific requirements.

3.2.4.3 The AWS electronics should be located on the southern side of the instrument enclosure. The box itself potentially constitutes an obstruction and, as such, must be correctly positioned outside the enclosure proper. The dimensions of the box should be as small as possible with the greatest dimension not to exceed 1 metre.

3.2.5 Airports without Bureau Staff

3.2.5.1 The pressure sensor should be installed with the console so that pressure readings may still be obtained in the event of a failure of the remainder of the AWS, or with its communications link to the other sensors.

3.2.5.2 The temperature and humidity sensors shall be installed in an approved shelter with the base at a height of 1.1 metres above ground level. (See also instrument shelter section.)

3.2.5.3 The rain gauge shall be installed in accordance with the criteria specified in the rain gauge section of these specifications.

3.2.6 AWS not at Airports.

3.2.6.1 The pressure sensor should be mounted in the AWS approximately 300 mm above the concrete base of the AWS.

3.2.6.2 The temperature and humidity sensors should be installed in an approved shelter with the base at a height of 1.1 metres above ground level. Exceptions to this may be made where the AWS is in an area subject to accumulations of snow. The shelter should be movable or, if this is impractical, be mounted at a level above the highest expected accumulation of snow for that location.

3.2.6.3 The rain gauge and any other instruments connected to the AWS shall be installed as per their normal exposure requirements.

3.3 Pressure Sensors.

3.3.1 The pressure measured should be the static pressure of the atmosphere at a specified reference level. This measurement is referred to as the station level pressure. The barometer elevation needs to be surveyed to an accuracy of 10 cm, and be cross referenced to both the aerodrome reference point (for airport installations) and the Australian National Geodetic Grid.

3.3.2 A barometer will not give a true reading of static pressure if it is subject to the influences of gusty winds. The amount of the fluctuation is dependent upon the geometry of the building and its openings. It may be necessary to relocate the barometer to a more sheltered location if this becomes a serious problem, or to fit a static head to the barometer.

3.3.3 Barometers must not be installed in "sealed" buildings, where the air pressure inside the building is liable to be different to that outside.

3.3.4 Mercury barometers.

3.3.4.1 These should be placed in a room in which the temperature is constant or changes only slowly, and in which temperature gradients do not occur. They should be shielded from direct sunshine at all times and should not be placed near any heating or cooling device. It is preferable to hang a mercury barometer on a solid inside wall which is free from vibration. Accurate work, the best position is in an insulated, unheated windowless room, such as a basement, with a small fan to prevent any stratification of temperature.

3.3.4.2 Artificial lighting is required to maintain uniform conditions for reading the barometer. The meniscus must be provided with a light wall or board as the background. The lighting must not heat the barometer.

3.3.5 Aneroid barometers**.**

3.3.5.1 Most aneroid barometers used for meteorological purposes are temperature compensated for fluctuations in temperature in the ranges likely to be experienced in sheltered conditions in Australia. However, they should be protected from differential heating from direct sunlight, heaters or any form of air conditioning.

3.4 Instrument Enclosure.

3.4.1 The instrument enclosure may contain variety of instruments. For a standard Bureau staffed observing station, the instrument enclosure is a 17 metres by 17 metres square enclosure in the middle of a 30 metre by 30 metre square buffer zone aligned in the true North - South direction. The selection of the site must cater for the exposure requirements of the most sensitive instrument to be installed in the enclosure and the primary purpose(s) of the instruments (e.g. for aviation, synoptic, climatological, agrometeorological and other purposes). *See Attachment 4 for the Instrument Enclosure diagram*.

3.4.2 The enclosure area is to be level, clearly defined and covered with as much of the natural vegetation of the area that can be kept cut to a height of a few centimetres. The enclosure area should not be artificially watered. Concrete or asphalt walkways should be kept to the minimum number, only being installed where the surface is likely to be rendered impassable or unsafe in wet conditions, and in any case be no wider than 0.5 metres.

3.4.3 The buffer area around the enclosure must also be covered by the natural vegetation or ground cover of the region which can be maintained below approximately 0.5 metres in height.

3.4.4 As a general guide, the distance of any obstruction less than 15 metres in height and of an isolated nature from any point in the enclosure is to be at least 4 times the height of each obstruction away from the enclosure. This criterion also applies to the AWS electronics box.

3.4.5 For obstructions of a greater height than 15 metres or of a more general nature, the distance to the enclosure will need to be increased (up to 10 times the height of the obstructions if they cover more than 45° of azimuth) . Isolated thin masts closer to the enclosure may be acceptable, particularly if they do not obstruct direct solar radiation from falling on the enclosure, and lie down wind of the prevailing winds in rain situations.

3.4.6 Refer to the siting and exposure requirements of the individual instruments for full requirements, particularly if an anemometer or solar radiation instruments are to be located in or alongside the enclosure.

3.4.7 Refer also to the "Instrumentation at Airports" section for obstacle limitation surfaces near areas used by aircraft.

3.5 Anemometers.

3.5.1 General considerations.

3.5.1.1 In most instances, an anemometer is required to provide a wind reading which is representative of a relatively large area, such as an entire airport or a district. For these applications, ideally anemometers should be exposed over level terrain at a standard height of 10 metres above the mean ground level at locations completely free of all obstructions to the air flow. More details concerning the physics of airflow in the boundary layer can be obtained from appropriate reference texts (eg Stull, 1988).

3.5.1.2 This condition excludes those anemometers sited specifically to measure microscale wind regimes, such as wind run anemometers immediately above an evaporation pan, or to quantify non-representative or localised winds for dispersion studies, or to identify winds affected by local topographic features. The wind measurements from these types of sites cannot be extrapolated to other, relatively nearby locations.

3.5.1.3 The WMO stipulates that anemometers must be sited in open terrain, where open terrain is defined as an area where the distance between the anemometer and any obstructions is at least ten times the height of the obstruction. This exposure, although adequate for general purposes, still places the anemometer within the zone of influence of the obstruction when the winds are of moderate speed. For greater accuracy, a clear zone of thirty times the height of the obstruction is required (see following discussion).

3.5.1.4 The effects of obstructions on the wind velocity field extend for considerable distances upstream and downstream from the obstructions, even at ten metre heights. The paragraphs that follow are intended to allow these effects to be estimated correctly and hence optimise the selection of the anemometer site.

3.5.1.5 In an undisturbed surface air flow, the wind velocity varies with height throughout a region known as the boundary layer. The depth of the boundary layer varies considerably, depending upon the prevailing meteorological conditions, particularly atmospheric stability, wind speed and surface roughness. In a neutral atmosphere with winds of moderate speed, the surface frictional effects reduce the speed of the wind below a height of approximately 1000 metres ("Manual of Meteorology"). This profile is approximately logarithmic and is described by the following equation (Stull 1988), as illustrated in Figure 3.5.1.

$$U = (u_*/K) \ln (z/z_0)$$

where U = mean wind speed.

u_*	=	friction velocity (representing surface stress).
K	=	von Karman constant (normally set at 0.4, though not universally agreed).
z	=	height, and
z_0	=	aerodynamic roughness length.

3.5.1.6 The aerodynamic roughness length varies with the terrain, and is a measure of how much the surface features are interfering with the surface airflow. The magnitude of the roughness length is smaller than the physical size of surface obstructions. Figure 3.5.2, from Stull 1988, illustrates a broad cross-section of aerodynamic roughness lengths.

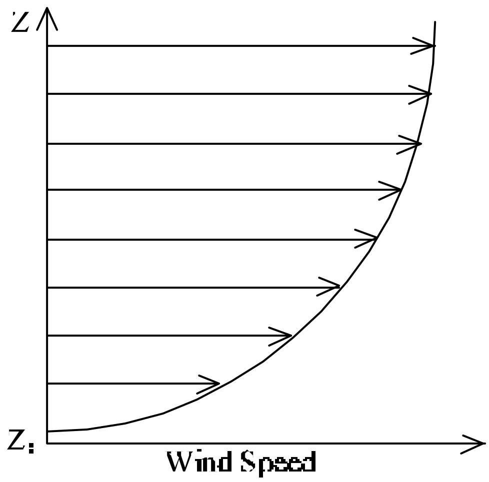


Figure 3.5.1 Typical logarithmic variation of wind speed with height in a neutral atmospheric boundary layer (after Stull, 1988).

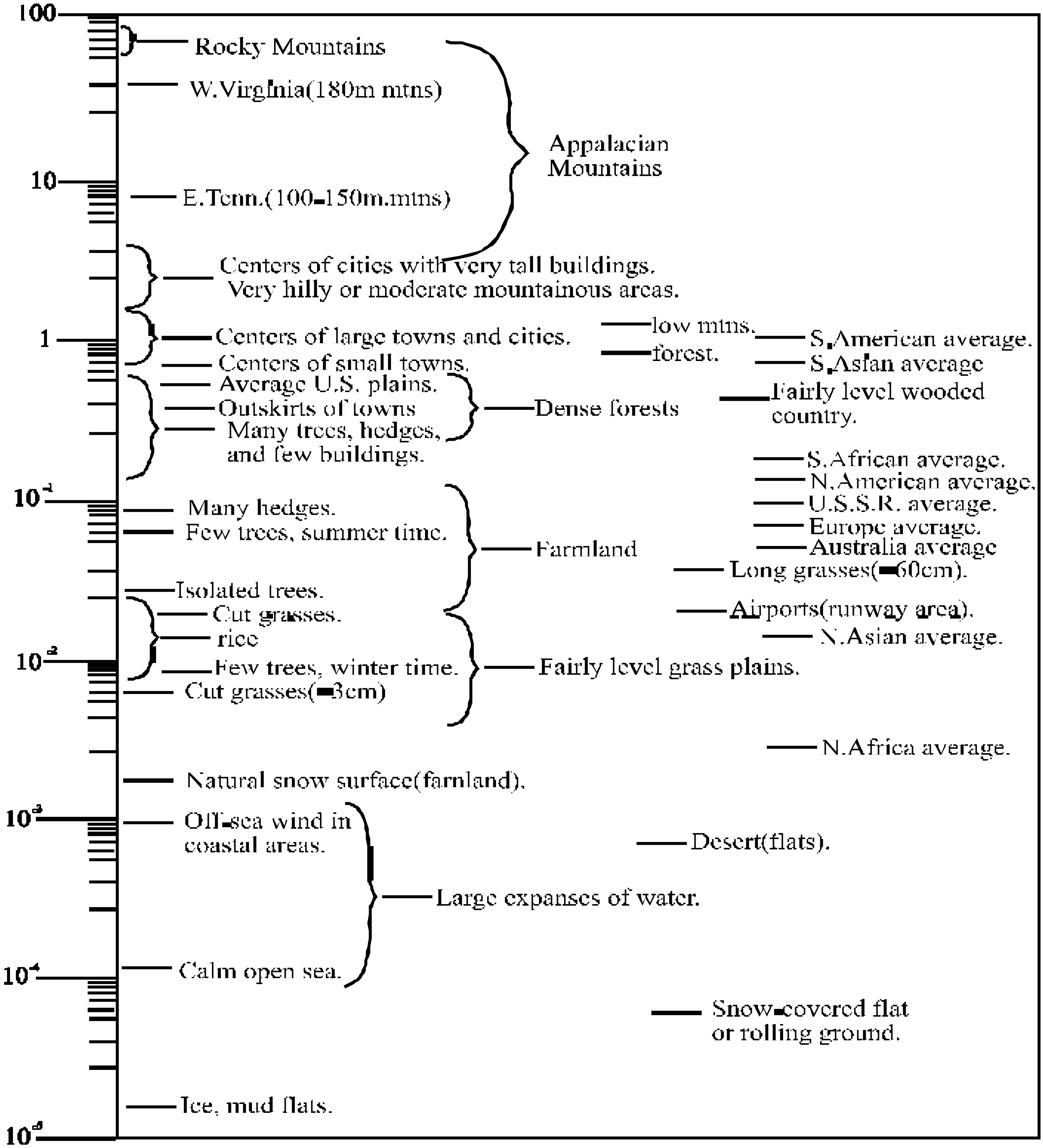


Figure 3.5.2. Aerodynamic roughness lengths. (R.B.Stull. "Boundary Layer Meteorology 1988").

3.5.1.7 The wind profile in the near surface layer is significantly affected by the stability of the layer, as illustrated in Figure 3.5.3. This illustrates why it is very important to standardise the height of all anemometers in the network as the application of correction factors to account for different exposures is approximate at best and prone to error. Australian Standard AS 1170, Part 2 wind Forces, tabulates variations of design wind velocities as a function of height and terrain type (or roughness).

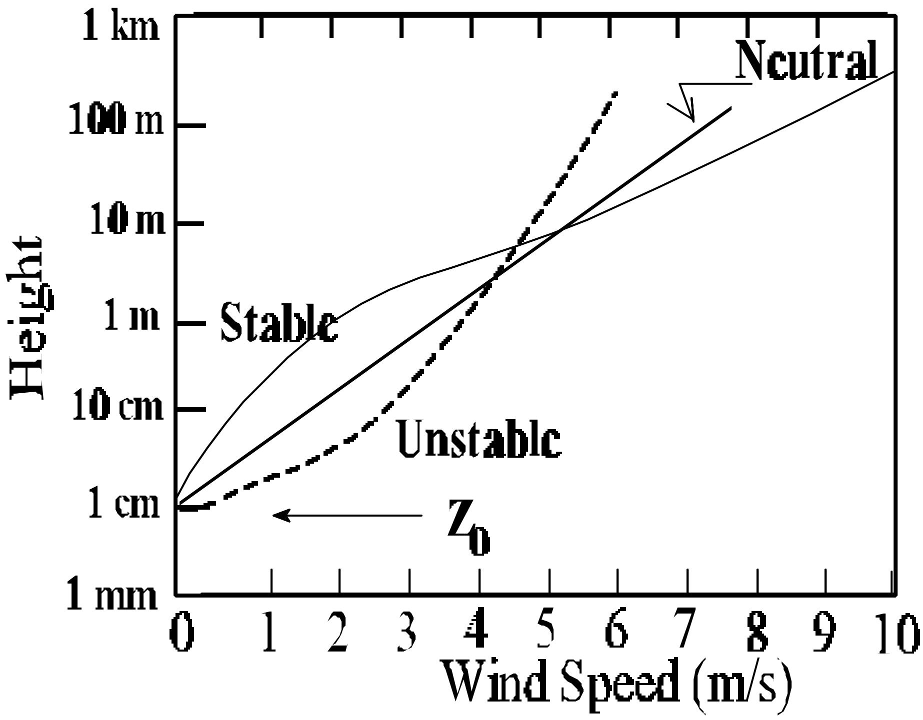


Figure 3.5.3 Typical variations in wind profile with stability in the near surface layer (after Stull, 1988).

3.5.1.8 When the wind encounters a large obstruction, the air will flow over, around and sometimes through it. The mean wind speed is reduced upwind of the obstacle out to a distance of about 10 times the height (h) of the obstacle. Reductions in the mean wind speed also extend downwind a distance of approximately 30 times the height of the obstruction (30 h), even when the obstruction is not solid. Considerable variations from this mean wind speed in both space and time are generated by the obstruction. In light wind conditions, the effects of obstructions are substantially reduced.

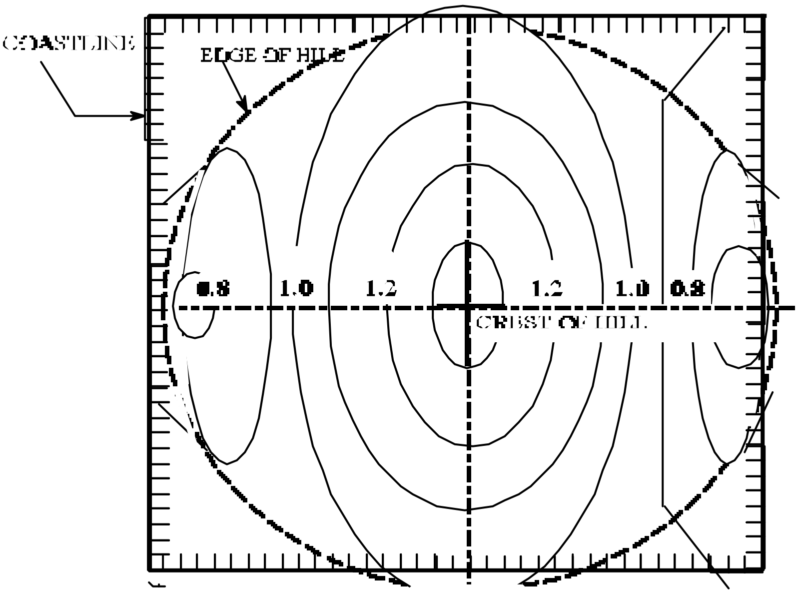


Figure 3.5.4 (a)

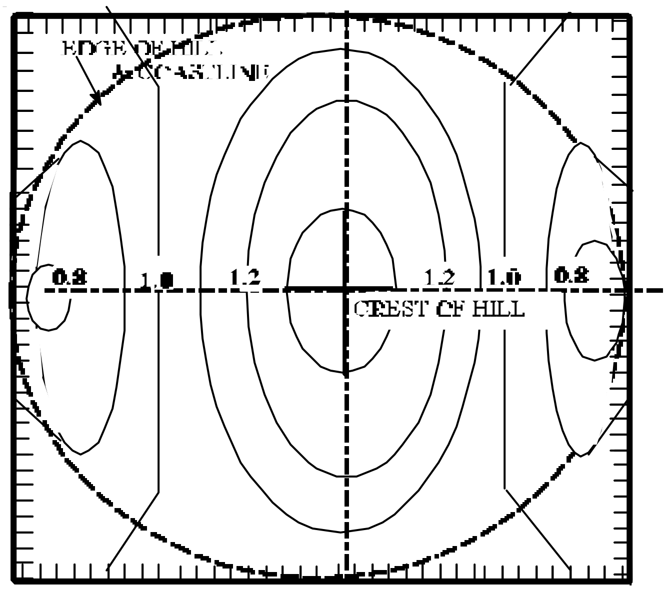


Figure 3.5.4 (b)

Figure 3.5.4 Normalised windspeed at 10 metres above ground level for (a) "100m high Coastal Hill of cosine-squared section" and (b) "Island" experiements. Contour interval is 0.1. (1.0 indicates no change to the initial wind field.) Edge of hill and coastline are indicated by heavy dashed lines. Point marks around the perimeter indicate grid spacing of 15.6m (Walmsley et al. 1986).

3.5.1.9 The near surface wind profile adjusts to the underlying surface roughness as a function of the fetch over that type of surface. AS 1170 tabulates the fetch/height relationship for different terrain categories one important implication of this when selecting a site for a coastal anemometer is as follows. If the intent is to obtain a representative wind over the open sea, a site very close to the coast is required. Even if the land surface is generally open with well scattered obstructions having heights in the range of 1 - 5 to -10 metres, (an aerodynamic roughness length of around 0.1 metre, close to the Australian average), the wind profile will have adjusted to this terrain within 100 metres up to the height of the anemometer. For rougher terrain, this adjustment is even more rapid.

3.5.1.10 The effects of hills and coastal topography are well illustrated in the literature (Taylor et al 1987, Walmsley et al 1986, Raithby et al 1987, Shepherd and Bally 1990). Several of these demonstrate the effects of topography based upon a detailed field study conducted at the Askervein Hill in Scotland. These references are strongly recommended for those who require higher accuracy wind information. Figure 3.5.4 from Walmsley et al illustrates these effects well in a more generalised way. It is essential to avoid cliff tops when siting an anemometer.

3.5.2 Isolated Obstructions.

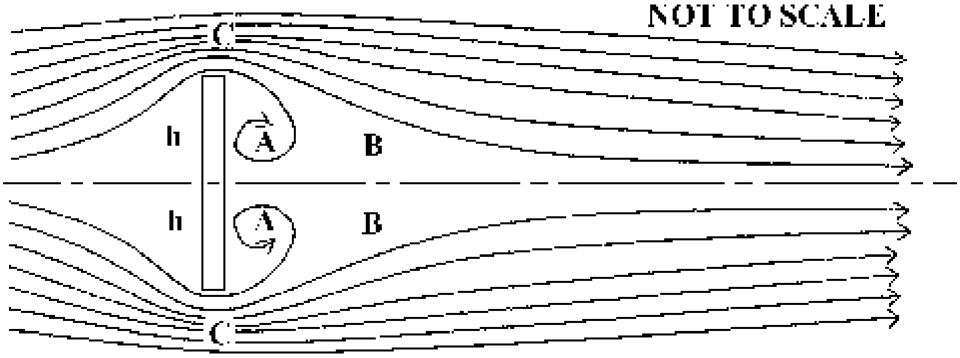
3.5.2.1 For isolated obstructions or for lone large obstacles, such as isolated rounded trees and towers, the effects of each of these must be considered when siting an anemometer. Where an obstruction is much wider than it is high, the height is the dominant dimension for assessing the wind effects.

3.5.2.2 For airflow past an isolated solid plate, the streamlines illustrating the distortions to the air velocity are typically as indicated in Figure 3.5.5.

3.5.2.3 There is a low velocity region (A) immediately behind the plate where eddies form, extending out to about 5h away from the obstruction. Mean wind speeds approach zero near the plate, but would be at a minimum at about lh to 5h downstream if the obstruction were permeable. The eddies can be quite violent for strong winds in real situations.

3.5.2.4 The sheltered wake region (B) has wind speeds lower than those found for the same height well upwind of the obstruction. This reduced wind speed region extends out to approximately 30 h downwind, although this distance is a function of wind speed.

3.5.2.5 The regions immediately to the side of the obstruction (C) have wind speeds higher by 10% or more than those at locations remote from the obstruction. This region extends out about 2h and also down wind, with the effect diminishing with distance.



A = Eddy or reversed flow regions.
B = Sheltered or wake regions.
C = Increased speed regions.

Figure 3.5.5 Airflow past a solid flat plate.

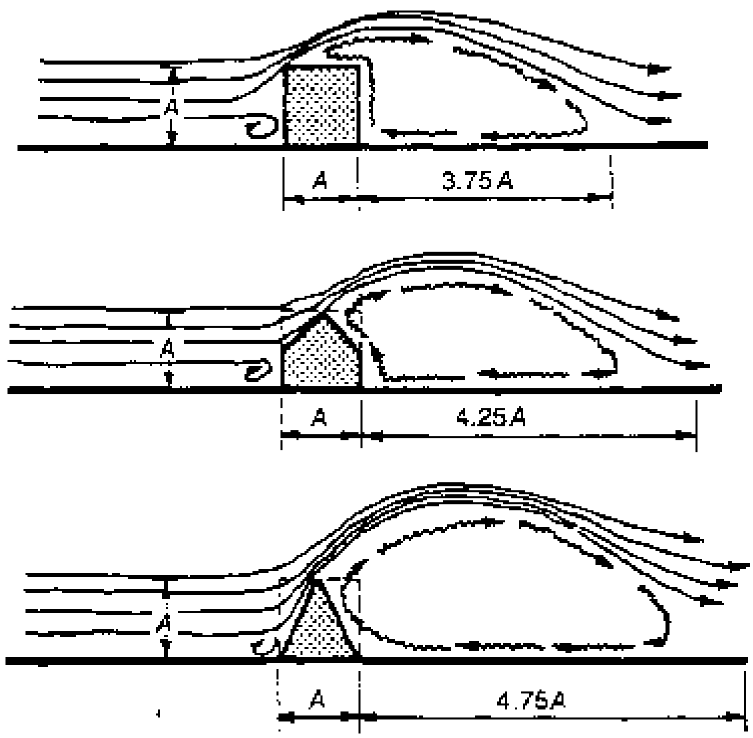


Figure 3.5.6 Airflow over buildings with different roof pitches (length equal to height) (AS 2923 - 1987).

3.5.2.6 Often, a lone obstruction may be a building. Figures 3.5.6 through to 3.5.8

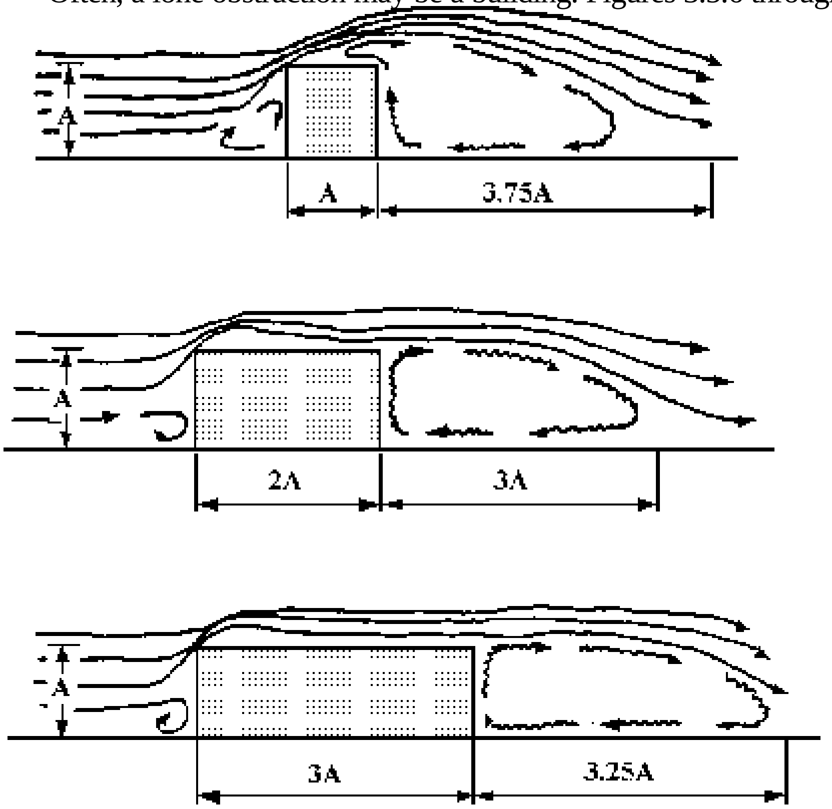


Figure 3.5.7 Airflow over flat roof buildings (AS 2923 - 1987).

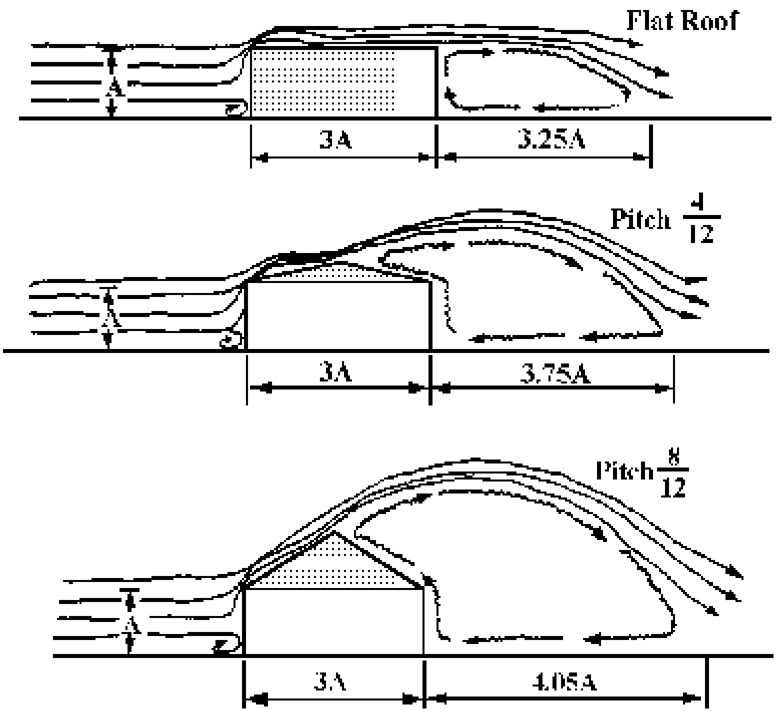


Figure 3.5.8 Airflow over different roof pitches (= 3 x height) (AS 2923 - 1987).

illustrate the effects of different roof pitches on the airflow.

The anemometer should therefore be exposed as indicated in Table 3.5.1, for obstructions 12 metres or more in height. (See paragraph 3.5.2.9 for standard 10 metre exposures) - Anemometers installed lower than these heights or closer to the obstructions will report wind speeds that are generally unrepresentative of the mean wind.

Distance to obstruction.	Minimum Height of Anemometer.
h	1.75h
5h	1.67h
10h	1.50h
20h	1.25h
25h	1.13h
30h	1.00h

Where h =obstruction height, for obstructions 12 metres or more in height.

Table 3.5.2.1. Anemometer exposure heights.

3.5.2.7 When the obstruction is permeable, the wind speeds down wind will be a combination of the reduced wind flow and that passing over or around the obstruction.

3.5.2.8 The wind profile existing well before the obstacle will be found again at around 30 h distance and beyond, and the 10 metre height wind at these distances will be very close to the true value. In the field it is very difficult to estimate the wind profiles near obstructions as these may be of all shapes and sizes. Therefore, as an approximation, the 10 metre wind speeds can be taken as those measured at or just above the minimum heights given in Table 3.5.2.1.

3.5.2.9 Setting the anemometer height to 10 metres, the minimum separation between the anemometer and obstructions must be as indicated in Table 3.5.2.2 for consistently accurate readings. (Note: The WMO currently have a more general, but less accurate, rule for the siting of anemometers of ten times the height of the obstruction).

Obstruction Height (h)	Factor	Min. Distance to Anemometer.
4.0m	x 10h	40 m
6.0m	x 10h	60 m
7.0m	x 10h	70 m
8.0m	x 20h	160 m
9.0m	x 28h	250 m
10.0m	x 30h	300 m

Table 3.5.2.2. Minimum Anemometer - Obstruction Distances.

3.5.3 Extensive Obstructions

3.5.3.1 Under most circumstances, the installation of an anemometer in an area where there are extensive obstructions should not be attempted. However, if it is essential to install an anemometer in such an area, the procedure outlined in the paragraphs that follow should be adhered to.

3.5.3.2 When the obstructions around an anemometer are numerous and of approximately the same height above the ground, the airflow over the obstructions approximates that over flat terrain, although it is inherently more variable in space and time. The anemometer must, therefore, be installed at a height which is 10 metres above the effective height of the obstructions. For example, should the mean height of low obstructions such as low buildings and small trees be about 6 metres, the anemometer will need to be installed on a mast 16 metres above ground level. The measured velocity from an anemometer with this exposure is as close to the equivalent wind velocity over open ground as the site restrictions will allow.

3.5.4 Wide Obstructions.

3.5.4.1 When obstructions subtending angles of more than 10^{O} are encountered, particularly when they are around 10 to 12 metres in height, it is wise to extend the minimum distance to 350 metres from these obstructions. Even so, if the large obstruction is to be tolerated, then every effort should be made to locate the anemometer where the obstruction will have least effect on the prevailing wind regime.

3.5.5 Thin Obstructions.

3.5.5.1 Where an obstruction is thin, for example, a mast, pole or thin tree, the air can quite readily flow around the obstruction, with the wind profile re-establishing itself a much shorter distance down wind. Experience has shown that the effective shielding distance for poles is approximately 30 times the half width of the poles. The principle explained in Figure 3.5.1 applies in this case, except that the width of the obstruction, rather than the height, is the determining factor. It should be noted that the effects of round or streamlined objects are much less than for flat sided objects. In practice, most obstructions also create a train of vortices down wind, so the minimum separations outlined should be observed at all times.

3.5.6 Building Mounted Anemometers.

3.5.6.1 The installation of an anemometer on a building should be avoided if at all possible as the measured wind can easily differ from the wind representative of a wider area by -50% to +100% in speed and by 90^{O} or more in direction. Buildings generate vortex trains which propagate down wind and create an area of increased wind speed over them (see Figure 3.5.5). For more discussion on the effects of different shape buildings, refer to Melaragno (1982) and AS 2923-1987.

3.5.6.2 If no alternative site is available the anemometer should be installed on a roof top mast which is free from the effects of the building itself (see AS 2923-1987 for details). The required height of the anemometer will be very dependent upon the design of the building itself and a calculation of these effects should be made before selecting the height of the anemometer. A correction must then be applied to the measured wind speed to make it approximate to the standard 10 metre wind, bearing in mind the shortcomings of this correction outlined earlier. Table 3.5.6 illustrates approximate correction factors that can be applied for neutral atmospheric stability. These factors will alter as the stability of the boundary layer alters and should only be used as a rough guide. The effective height of the anemometer has to be estimated to take into account other obstructions in the vicinity.

Effective Height	Correction
3 - 4 m	+ 20 %
5 - 7 m	+ 10 %
8 m	+ 5 %
9 - 12 m	zero
13 m	- 5 %
14 - 22 m	- 10 %
23 - 42 m	- 20 %
43 - 93 m	- 30 %

Table 3.5.6 Approximate correction factors to convert non-standard exposures to 10 metre exposures for conditions of neutral atmospheric stability.

3.5.6.3 An alternative method to adjust the wind speed from a non-standard height (V_h) to the standard ten metre exposure (V_{10}) that has found wide acceptance (although it remains an approximation with no allowance for factors such as roughness length and atmospheric stability) is the power law formula

$$V_{10} = V_h (10/h)^x \qquad \text{where } x = 0.13.$$

3.5.7 For Aerodrome Observations.

3.5.7.1 The anemometer which provides the wind readings for the aerodrome observations should be representative of the mean wind over the whole runway complex at a standard level above ground, which is set at 10 metres for Bureau equipped aerodromes. The preferred location is normally near the geometric centre of the runway complex, or close to the intersection of two runways. The separation distances between obstructions and the anemometer may, however, cause the anemometer to be located at another part of the airport.

3.5.7.2 In many instances, the wind field over the airfield is not homogenous, particularly for large airfields with multiple runways and significant topographical features in the vicinity. In this case, multiple anemometers should be installed at locations which identify the microscale variations in the wind field.

3.5.7.3 These anemometers may be a part of a wider system, such as an anemometer network which monitors the winds at the touchdown and lift-off zones of the runways, or a low level wind shear alert system. The mean wind then becomes a vector average of a selected group of anemometers which best represents the wind field over the airfield. However, in practice, it is common, though less accurate, to nominate one anemometer as "the airport anemometer".

3.5.8 For Runway Observations.

3.5.8.1 Aircraft operating near the lift-off and touch down zones of a runway are most susceptible to variations in the wind. Longer runways may require additional anemometers to better measure the wind field at these locations. The anemometers should be located alongside the runways at these locations, subject to the restrictions of the obstacle limitation surfaces and the need to minimise the anomalous reports caused by wing tip vortices and engine exhausts.

The latter require minimum clearances as follows:

Area.	Clearance.
Turning areas and aprons	150 metres
Runways	120 metres
Taxiways	75 metres

3.5.9 For Low Level Windshear Alert Systems (LLWAS).

3.5.9.1 Low level windshear is a significant hazard to aviation during the most critical phases of their operations when the aircraft are below 500m above ground level, notably the final approach and the take-off. Wind shear is a transient phenomenon and is not adequately detected by any one system. The low level windshear alert system (LLWAS), a network of anemometers, has been developed which detects horizontal wind shear over key areas of the runways and the approach and departure corridors, such as that associated with microbursts, thunderstorms and frontal systems, with the greatest possible probability of detection (POD) and the lowest possible false alarm ratio (FAR).

3.5.9.2 LLWAS anemometers are very sensitive to site caused fluctuations in the wind field and the need to site them correctly is paramount if the system is to work. The required network requires a comprehensive airport dependent study to be completed to identify the correct sites. Briefly, the anemometers must be positioned to form a network of triangles that are as close to equilateral as possible over the areas to be protected, noting that the area within about 100 metres of the anemometer itself is treated as a blind spot. Maximum separation of anemometers is 2.8 kilometres as greater distances are unable to suitably resolve the occurrence of phenomena such as microbursts, with angles in the triangles formed between neighbouring anemometers lying between 25^{O} and 135^{O}.

3.5.9.3 Requirements for siting anemometers for LLWAS are critical and complex. Refer to U.S. FAA order 6560.21 for details.

3.6 Instrument Shelter.

3.6.1 When selecting a site for the measurement of air temperature (maximum, minimum, dry bulb and wet bulb, whether by mercury or electrical thermometers), care has to be taken to ensure that the site is representative of the area of interest. Only shelters approved by the Bureau shall be used as the design of the shelter has a marked influence on the readings of the thermometers inside the shelter.

3.6.2 If at a manned Bureau station, the thermometer shelter shall be installed in the instrument enclosure as specified in the Bureau's instrument enclosure diagrams. In all cases, the base of the shelter shall be 1.1 metres above the level of the surrounding ground. The bulbs of the thermometers and/or the electrical transducers in shelters of the Instrument shelter type should be at a height of approx 1.2 metres above ground level.

3.6.3 In areas where snow accumulates, provision should be made to raise and lower the shelter to maintain a constant height above ground (snow) level, unless the site is to be unmanned. In this case, if it is believed that the shelter may become buried by snow, it should be installed above the highest expected level for the accumulation of snow.

3.6.4 If a shelter is required at locations where no instrument enclosure is to be provided, it must be installed in an area that is level and covered with either the natural vegetation of the area or unwatered grass, which needs to be kept trimmed to a few centimetres in height. The site should not be in a hollow or on a steep slope. The shelter should be freely exposed to the sun and wind, and not shielded by or close to trees, buildings, fences, walls or other obstructions. It should also not be close to extensive areas of concrete, asphalt, rock or other surfaces which may locally alter the air temperature at the site. In areas where these surfaces are unavoidable, a minimum clearance of 5 times the width of the unrepresentative surface is recommended.

3.6.5 Although free flow of air through the shelter is required, the shelter should not be located in an area where the wind speed will be sufficient to cause it to vibrate, except under extreme conditions. Additional bracing may be required in some cases.

3.6.6 For instrument shelters, the shelter shall be oriented true north-south with one or two doors, depending upon latitude, to ensure that direct sunlight does not fall on the sensors when the (appropriate) door is open.

3.6.7 Shelters shall not be installed on the tops of roofs, or near the exhausts or heat exchangers of such equipment as air conditioners, refrigerators and the like.

3.7 Terrestrial Minimum and Soil Temperature Thermometers.

3.7.1 The terrestrial minimum thermometer should be installed in the most open position available within the instrument enclosure. Detailed installation instructions are contained in the B.O.M. Surface Observations Handbook.

3.7.2 Thermometers that measure the temperature of the soil at varying depths (typically 10, 20, 50 and 100 cm) shall be located within the instrument enclosure in accordance with Meteorological Equipment Layout Drawing No. SI-01-01. Siting requirements for the soil temperature thermometers are as follows:

- The site should be a level plot of bare ground 1.8m x 1.8m;

- Thermometers should not be in shadows cast by other instruments while the elevation of the sun is 3^{O} or greater above the horizon;

- Thermometers should not be placed in a hollow where water can accumulate, or be located where the ground becomes wet from a tap in the enclosure, or run off from recording rain gauges, spillage from an evaporation pan or water used to wash the instrument shelter;

- The soil should be representative of the soil for the locality and should not have been unduly disturbed by civil works; and,

- The water table should not rise to the level of the deepest thermometer.

3.8 Precipitation Gauges.

3.8.1 General considerations.

3.8.1.1 Precipitation is one of the more difficult meteorological elements to measure accurately. Extensive research work into the best techniques to measure precipitation continues. WMO No. 328 provides a broad coverage of the issues relevant to the measurement of precipitation.

3.8.1.2 For most applications, a precipitation gauge should be located near the geographic centre of the area for which it is intended to represent in lowlands and level areas. For mountainous areas, the gauges should be installed at or slightly above the mean altitude of the representative area.

3.8.1.3 The amount of precipitation measured by a rain gauge, snow gauge or a pluviograph is affected by a variety of factors. The deformation of the windfield over and around the gauge can greatly alter the amount of precipitation collected. This problem is exacerbated by strong winds and is affected by the geometry of the gauge, the slope and roughness of the surrounding terrain and the presence of forests and buildings. The exposure of the gauge to the effects of the wind greatly varies the catch efficiency of the gauge. Snow catch is affected significantly more by wind effects than is liquid precipitation.

3.8.1.4 The height of the gauge orifice above ground level is a critical factor which affects the amount of precipitation captured by the gauge. The wind speed increases rapidly with increase in height for the lowest few metres of the atmosphere, which means that measured rainfall decreases as the height of the gauge orifice above the ground increases.

3.8.1.5 Within approximately the first few cms above ground, in moderate or heavy rain, a substantial amount of precipitation may splash into the gauge from the ground. A small proportion of the incident rain also will splash out of the gauge. Solid precipitation may clog the gauge, and hail may bounce out of it.

3.8.1.6 From the above discussion it becomes evident that a degree of sheltering of the rain gauge is very desirable to reduce wind effects over the gauge orifice. The ideal situation is for uniform sheltering surrounding the gauge such that the wind velocity across the orifice is reduced to zero. The general wind field in the area surrounding the gauge must not be deformed by surrounding obstacles. Sheltering obstacles must not themselves be intercepting the incoming rain. It is therefore difficult to set a uniform exposure guideline. In the typically encountered situation with irregular obstructions, it is best to aim for no obstructions above a slope of 1:2. Where the obstructions are concentrated in a sector, a 1:4 obstruction free slope is preferable. Thus, a clear area surrounded by uniform forest, buildings, etc which reduce the airspeed over the rain gauge to near zero without unduly disturbing the general airflow of the area and not intercepting any of the incoming rain constitutes the best exposure for a standard rain gauge.

3.8.1.7 When selecting a site for a rain gauge, attention should be given to finding a site with uniform obstructions in the surrounding area, avoiding areas with high obstructions alongside clear pathways. For example, in the urban environment it is better to locate the gauge in a backyard on the opposite side to the driveway as the driveway can create a local wind tunnel effect, significantly increasing the wind velocity in its vicinity. This would greatly reduce the rainfall catch in a gauge if positioned immediately alongside the driveway.

3.8.1.8 It should also be noted that wire fences (eg cyclone fences) are relatively effective at reducing the wind speed without producing the number of eddies and wind distortions that solid fences produce. It is better to locate a rain gauge near a wire fence than near a solid fence.

3.8.1.9 In general, it is undesirable to locate a rain gauge on a fence or a pole. However, should a site be found with uniform obstructions over the surrounding area (radius in the order of 50 metres) at a given height (say, for example, 2 metres) , positioning the gauge on a pole that would give the gauge an effective 1:4 exposure above these obstructions may be justified.

3.8.1.10 For a significant proportion of the time, rain gauges in many Australian locations are significantly heated by direct solar radiation, or from heat transferred to the gauge from the ground. The effects are worse for the ground based gauges, which can suffer from loss of rainfall through evaporation. It is therefore important not to exacerbate this problem by mounting the gauge on a concrete block or similar surface.

3.8.2 High Accuracy Rainfall Networks.

3.8.2.1 It is difficult to fully overcome the problems outlined in the previous section in a practical and economic manner for a large network of gauges. For special purpose small networks requiring high accuracy, the following techniques can be used, in order of decreasing efficiency, to reduce the effects of deformation of the wind field by the gauge:

3.8.2.1.1 Install the gauge in an area of homogeneous dense vegetation, with the vegetation being kept trimmed to the level of the gauge orifice;

3.8.2.1.2 Install multiple fence structures around the gauge to simulate the effects of 3.8.2.1.1.; or

3.8.2.1.3 Use special wind shields around the gauge. Care must be taken to select the correct type of wind shield or the expected improvements in performance may not be achieved.

3.8.2.2 Rain gauges can also be installed with the opening level with the ground in a special, drained pit surrounded by a splash guard, provided it is in a snow free area.

3.8.3 Measurement of Snow Fall.

3.8.3.1 The reliable measurement of snow has been demonstrated to be highly inaccurate, particularly in regions where wind velocities are high. It becomes almost impossible in blizzard conditions to distinguish between newly fallen snow and snow that has blown from elsewhere. These adverse conditions are common in most parts of Australia and the Antarctic where snow is likely to fall, making most snowfall measurements meaningless.

3.8.3.2 If the measurement of snowfall is to be attempted, the following options are recommended:

- In areas where snow is likely to be regularly experienced and the mean wind speed seldom exceeds 15 m/s, the best technique is to surround the gauge with a Tretyakov-type wind shield and a Valdai double fence, as illustrated in Figure 3.8.3. The height above ground level of the gauge orifice should be standardised at 2 metres, unless it is thought that accumulations of snow will bury the gauge. The Tretyakov shield and Valdai double fence arrangement has been shown in field intercomparisons to be superior to gauges using the Nipher shield, or no shield at all.

- In areas where the wind speed is likely to consistently exceed 15 m/s, which includes much of the high alpine country and the Antarctic, it is recommended that snow depth data be recorded instead. The most reliable measurements would be from broad basins where significant but representative snow accumulations are known to occur, but away from features which cause localised, unrepresentative snow drifts. Current studies indicate that acoustic or ultrasonic sensors mounted on arms to the side of poles provide reliable and accurate measurements of snow accumulation (see WMO No. 328 Pp 217 -220). The integrated snow depth throughout the year can then form a climatology for long term climate studies.

- New optical devices (eg the optical rain gauge) have the potential to measure snowfall more accurately than conventional gauges. These may be mounted on

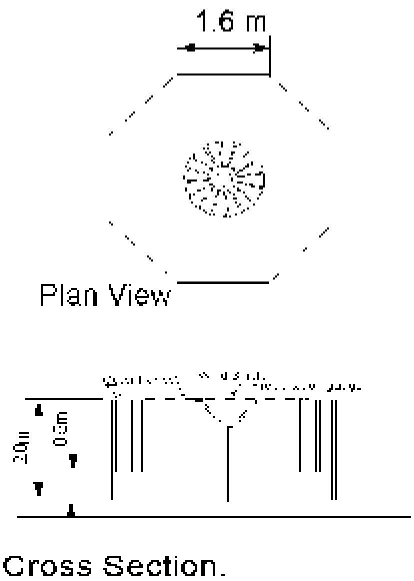


Figure 3.8.3 Siting requirements for a precipitation gauge in snow prone areas with wind speeds below 15 m/s (WMO No. 328, 1989).

poles to raise them above the worst of the drifting snow. Wind effects are greatly reduced with this type of sensor. However, it is best to locate them in areas removed from the worst of the blizzard conditions.

- If staff are available, it is desirable to take snow cores at regular intervals from an identified, well exposed area of snow. These snow cores are then melted to determine the water equivalent of the snow, overcoming differences in snow density that decrease the accuracy of depth-only measurements.

3.8.3.3 Heaters are required in the collector of the conventional gauge in areas where snow and other forms of frozen precipitation are likely to fall. Care should be taken to adjust the heating to a level just sufficient to melt the snow as the heating process increases the evaporation from the gauge.

3.8.4 Bureau Standard Raingauge Network.

3.8.4.1 For the Bureau's extensive rainfall network, it is impractical to implement the techniques that can be used for small, high accuracy networks. However, consideration must be given to reducing the adverse effects mentioned earlier. The difficulties in obtaining a good exposure when the gauge sits on the ground must be weighed against the adverse wind effects of an elevated gauge. This is particularly important for a gauge mounted on a fence or a roof where there is significant asymmetry in their exposure.

3.8.4.2 An increasing number of rainfall measurements are being automated. These automated sites can experience considerable growth of vegetation between routine maintenance visits, which can adversely effect the readings from gauges mounted close to the ground. In these situations, some form of vegetation suppression growth technique should be used (e.g. the use of a sheet of plastic covered by a thick layer of wood chips or other similar material). Also, gauges mounted on the ground are far more susceptible to the infestation by ants and other creatures that can adversely affect the operation of the gauge

3.8.4.3 In order to preserve the consistency in the climate record for existing rainfall stations with a long high quality record (provided the exposure of the rain gauge has not deteriorated in this time) the gauge should be left at its current exposure until such time as a dual observation program is completed for that site.

3.8.4.4 The special warning requirements of the hydrological flood warning ALERT system may necessitate a non-standard exposure of the rain gauges in some instances. However, the number of these should be kept to the absolute minimum and they should not form a part of the rainfall climatological data base.

3.8.4.5 The Dines syphon pluviograph's physical dimensions means that the orifice may be up to 1 metre above ground level. Although this height is accepted for existing Dines installations, it is expected that replacement pluviographs will have an improved exposure conforming to 3.8.4.6.

3.8.4.6 Under all other circumstances, in order to establish consistency across the network, the following constitutes the recommended standard exposure for all newly installed rain gauges, including tipping bucket rain gauges, Dines pluviographs and the Australian standard gauge, in normal Australian conditions :

- For fully instrumented stations with an instrument enclosure, the rain gauge shall be positioned as per the standard Bureau instrument lay out, with the provisions that follow also being met.

- The height of the gauge orifice should be 300 mm above the ground. Where local effects indicate this height is totally impractical and all avenues to find a site with a suitable exposure have been exhausted, heights of between 300mm and 1 metre may also be accepted, provided the reasons for the departure from the standard exposure are clearly identified on the station history file.

- Objects should not be closer to the gauge than twice their height above the gauge's orifice, with a distance of four times their height being optimal.

- The gauge should be mounted such that the surrounding surface (within 1 metre) is covered by short grass, or a semi-porous, slightly irregular covering such as gravel, loosened soil, etc, where these are the naturally occurring surfaces of the area. Hard, flat surfaces, such as concrete, asphalt and rock should be avoided as these lead to excessive in-splashing. These types of surfaces may also raise the temperature of the gauge more than is normal from direct radiation, which may lead to excessive evaporation of the precipitation captured by the gauge.

- In snow-prone areas, a site sheltered from the wind as much as possible by obstructions in the middle distance (i.e. in the range of 50m to 100m from the gauge) should be chosen. The gauge should be mounted above the highest expected level of accumulated snow for that location.

- In very windy areas (e.g. exposed islands, headlands), the use of optical rain gauges should be considered.

3.8.4.7 For shipboard or platform based gauges, correct exposure is difficult to achieve and a case by case evaluation has to be made.

3.9 Present Weather Sensors.

3.9.1 Present weather sensors, such as the light emitting diode weather indicator (LEDWI), must be sited at a location typical of the area of concern, avoiding hollows where fog may linger and areas where anomalously high winds may occur. The exposure is similar to that of a rain gauge, except that the sensor should be at a height of approximately 1. 5 metres above ground level to completely remove it from the zone affected by splashing of rain off the ground.

3.10 Evaporation Pans.

3.10.1 The exposure of devices for the measurement of evaporation is dependent upon the type of device being used. It should also be noted that readings from one type of device are not readily comparable with those from another. The Bureau of Meteorology has been using Class "A” evaporation pans equipped with bird guards to measure evaporation to estimate water loss from a natural surface and these will be considered here.

3.10.2 The rate of evaporation is largely dependent upon the temperature of the evaporating surface and the airflow across that surface. It is important to select a site where the airflow over the surface is representative of the mean airflow near the earth's surface for the region of interest. Areas where this airflow is either increased or reduced for any reason should be avoided so attention to local obstructions is important. Details of sheltering effects on evaporation measurements are contained in Hanson and Rauzi (1977), with general coverage of the principles involved also given in section 3.5 of this document.

3.10.3 In hilly or mountainous terrain, the evaporation pan should be sited on a plateau or level area of ground in order to produce the most representative measurements in an area of high evaporation variability.

3.10.4 The site requirements are:

- No obstructions which will cast a shadow onto the pan when the sun is at an elevation of 3^{O} or greater;

- The ground surface surrounding the pan must be relatively level and have the vegetative cover (trimmed to a few centimetres above the ground) comparable to that of the region;

- The pan must not be placed on concrete, rock, asphalt or other surfaces that may adversely affect the evaporation results.

- The distance of the pan from isolated obstructions which are higher than the top of the pan should be not less than ten times and preferably thirty times their height above the rim of the pan; and

- The pan is not closer than 1.5 metres and preferably 2.5 metres from any instrument higher than the pan.

- The site must not be subject to chemical contamination (eg from avgas) or to contamination by fallen leaves and twigs.

3.10.5 As the evaporation pan results are closely related to the windrun, the clearance distances to significant obstructions to the airflow over the evaporation pan should comply with those outlined in the anemometer section. A skyline survey should be prepared as viewed from the top of the evaporation pan in order to quantify its exposure.

3.11 Ceilometers.

3.11.1 All ceilometers require an obstruction free zone immediately overhead and should be installed on level ground or slight rises. To minimise the influence of local patches of fog. Localised areas of blowing dust should also be avoided to help keep the optics clean and, if possible, sites of lower atmospheric turbidity chosen. The site should be free from smoke or the effects of industrial air pollution.

3.11.2 The location of ceilometers for the determination of cloud base depends largely upon the number of units to be installed and their purpose. Early warning of the approach of low cloud from particular directions or the development of cloud in particular sectors may influence the location of ceilometers.

3.11.3 The following guidelines should be used as a general guide, particularly for aviation applications, bearing in mind the aforementioned:

3.11.3.1 For a single ceilometer, the ceilometer should be near the geometric centre of an airfield and close to the automatic weather station;

3.11.3.2 For multiple ceilometers, a site near the middle marker of each precision approach runway is preferred, with the additional benefit that the required power and communications facilities should already exist at these locations. In cases where this places ceilometers unnecessarily close together, they should be offset to the side of the middle marker site so as to improve the areal coverage of the ceilometer network.

3.12 Cloud Base Searchlight.

3.12.1 For a standard installation:

3.12.1.1 The beam shall be inclined at an angle of 63 deg. 26 min. (63.4 deg.) above the horizontal and point toward the observation point.

3.12.1.2 The baseline and the projected beam shall be in the same vertical plane.

3.12.1.3 From the observing point, the sky must be visible at the following elevation angles:
When facing toward the light: Between 10deg and 90deg.
When facing away from the light: Between 90deg and 60deg.

3.12.2 For a non-standard installation (i.e. a single searchlight with multiple observing points):

3.12.2.1 The beam shall be vertical.

3.12.2.2 From the observing point, when facing toward the light, the sky must be visible at elevation angles between 10deg and 90deg.

3.12.3 For all installations:

3.12.3.1 The baseline for the cloud base searchlight shall be between 150m and 250m.

3.12.3.2 The searchlight and the observing point should be as close to the same elevation as practicable.

3.12.3.2.1 The relative elevation should be determined to an accuracy of +/- 0.5m, and referenced to the official station elevation.

3.12.3.3 The observing point should be no more than 15m from the external door leading to the observer's office.

3.12.3.4 The area should be free from any lights close to the fields of view set out in 3.12.1.3 or 3.12.2.2, as applicable.

3.13 Runway Visual Range Equipment, including background luminance meter.

3.13.1 Runway visual range equipment (RVR) is used to obtain measurements of visibility along runways which are likely to be used during periods of reduced visibility. RVR readings are normally required at the touchdown zones at both ends of the runway and at the mid-point of the runway.

3.13.2 The units should be installed within 120 metres laterally from the centre of the runway, and should be as close to the height representative of the pilot's viewing position as possible, bearing in mind the obstacle limitation surfaces for the airport. Five metres is regarded as being representative of the pilot's view. As runway lights are near ground level, the average height of the light path to the pilot is around 2.5 metres. The normal limits for the height of the units above ground level is between 2 and 3 metres. The path of the light beam between the transmitting and receiving units should not be closer to the ground than 1.5 metres at any point. Disturbances to the optical path closer to the ground than 1.5 metres, that are not related to visibility reductions, become significant.

3.13.3 For the touchdown units, the units should be 300 metres along the runway from the threshold. The exact location of the units can be varied slightly, depending upon the baseline of the units used.

3.13.4 In theory, the background luminance sensor should be located so as to measure the brightness of the background against which the pilot would view the runway lights. The sensor, therefore, should look in the same direction as the pilot. However, as direct sunlight must be avoided and the runway lights must not influence the reading, a compromise must be found. For mid-latitude locations in Australia, the sensor should monitor the southern sky at an elevation of approximately 45^{O} at a location slightly awayfrom the runway.

3.14 Visibility Meters.

3.14.1 Visibility meters, such as forward and backward scatter meters, may also be used to obtain an estimate of visibility. As they sample an extremely small volume of air, their representativeness oflarger areas is at best tenuous. It is therefore imperative that the site selected for such a device is close to the geometric centre of the area of interest, avoiding fog prone hollows.

3.14.2 This type of device achieves a certain degree of acceptability by performing time integration to approximate spatial variations in visibility. Therefore, the visibility meter must be freely exposed to the weather elements and be remote from all large obstructions.

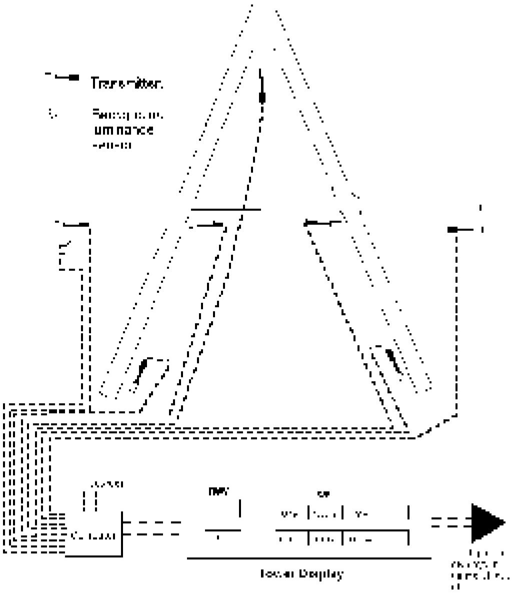


Figure 3.14.1 Diagram of an automated RVR system (WMO 731. 1990)

3.14.3 If used at an airport, multiple units may well be required. The siting principles employed for transmissometers should therefore be observed.

3.15 Video Surveillance Cameras.

3.15.1 Video cameras may be installed to provide supplementary information on general prevailing weather conditions. The video camera is not suitable for the estimation of quantitative parameters, such as visibility and cloud amount.

3.15.2 The video camera should be mounted so as to provide an unobstructed view of the horizon in all directions. The site should not be adjacent to strong lighting as this may adversely affect the performance of the camera.

3.15.3 At stations where there are sensitive or military operations, approval for the siting of the video camera must be obtained from the relevant authorities.

3.15.4 The distance from the video camera location to the display and control module should be kept to the minimum in order to reduce the deterioration in the video camera signal quality. Sites where a direct communications link can be installed, bypassing any switchboard, are preferred. This problem is removed if the video image is digitised on site.

3.16 Lightning /Thunderstorm Detection Systems.

3.16.1 These systems rely on the fact that a lightning stroke produces a strong radio wave which travels in all directions from the location of the stroke. The detection system can either be based upon the time of arrival of the radio wave, or the direction from which the wave arrives.

3.16.2 The remote antennae, particularly for directional systems, are best located in an open area free from metal structures, power transmission lines or rough terrain which may alter the path of the radio waves. The time-of-arrival technique sensors are less susceptible to site induced inaccuracies but open areas are still preferred.

3.16.3 Another device, a simple lightning stroke counter, may be installed at an open site free from human caused electrical discharges.

3.17 Solar Radiation.

3.17.1 The principal exposure requirement is freedom from obstructions for the area delineated in Figure 3.17.1 for stations from the Equator to 45^{O} South. For stations south of 45^{O} South, there should be no obstructions to within 3^{O} of the horizon. Horizon obstruction diagrams (skyline surveys) must be prepared and updated yearly. Thin masts and guy wires will not constitute obstructions provided that:

- If their elevations are greater than those indicated by curve B in Figure 3.17.1, the total azimuth subtended by them (i.e. the sum of the azimuth angles subtended by individual masts, etc) does not exceed 2^{O}.

- If their elevations are greater than those shown by curve A but less than those shown by curve B, the total angle subtended by them must not exceed 5^{O} (Note: Curves A and B are superimposed from 050 ^{O} to 130 ^{O} and from 230 ^{O} to 310 ^{O}.)

3.17.2 A full 360^{O} photographic panorama should also be prepared.

3.17.3 The site should be chosen so that the incidence of fog, smoke, suspended or blowing dust and airborne pollution is typical of the surrounding area.

3.17.4 Sites near areas of high albedo (i.e. surfaces with moderately or highly reflective surface) should be avoided.

3.17.5 The instruments should be mounted on a stable platform 1.5 metres above ground level, which will not vibrate, tilt or subside. If a suitably unobstructed site cannot be found at ground level, then a roof top location may be necessary, provided easy access is available at all times for the cleaning of the sensor optics.

3.17.6 If no site conforming to the above criteria can be found, a compromise site approved by the Bureau's solar radiation scientist should be used.

3.17.7 The difference in height between the station barometer and the solar radiation instruments must be determined.

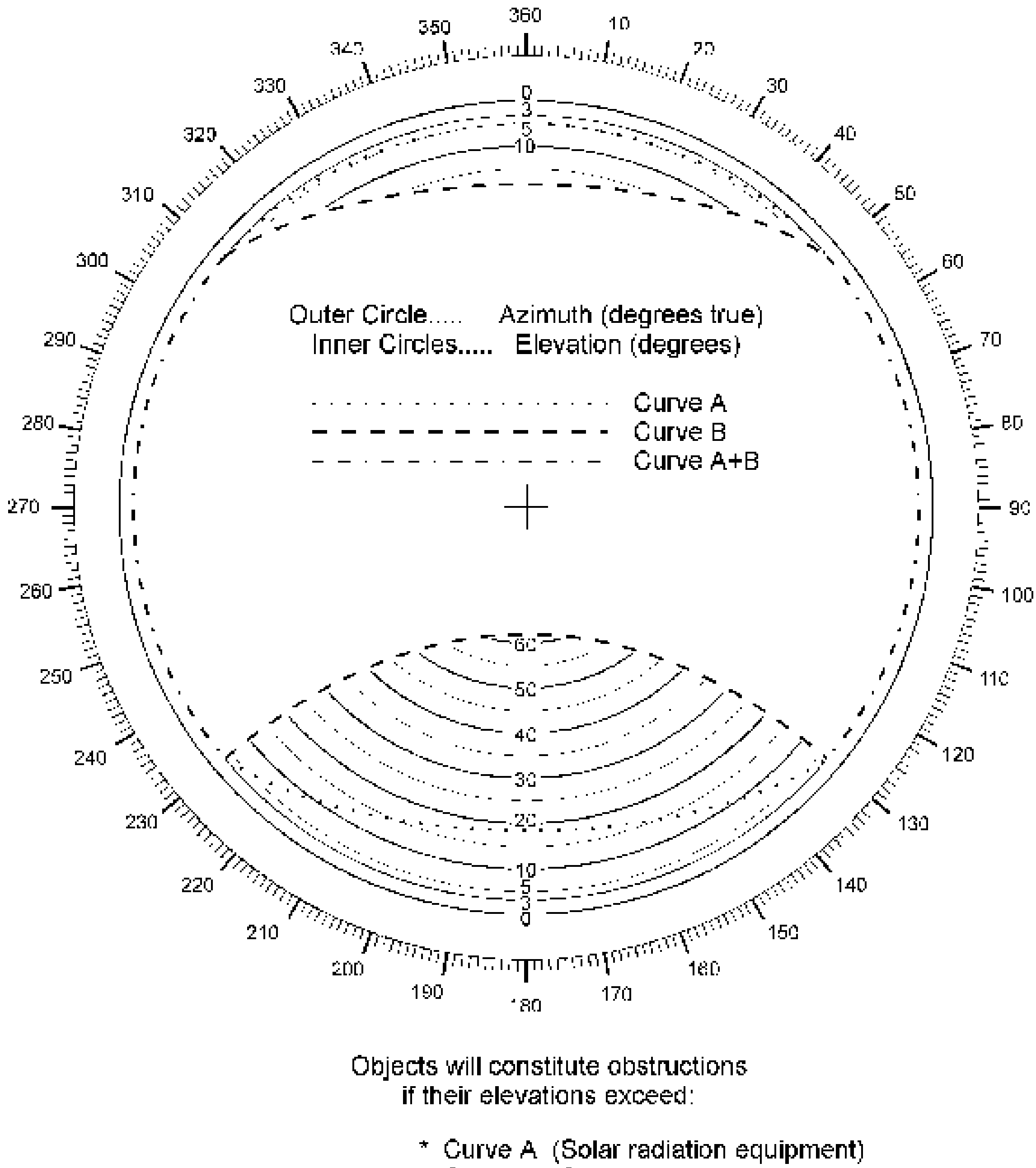
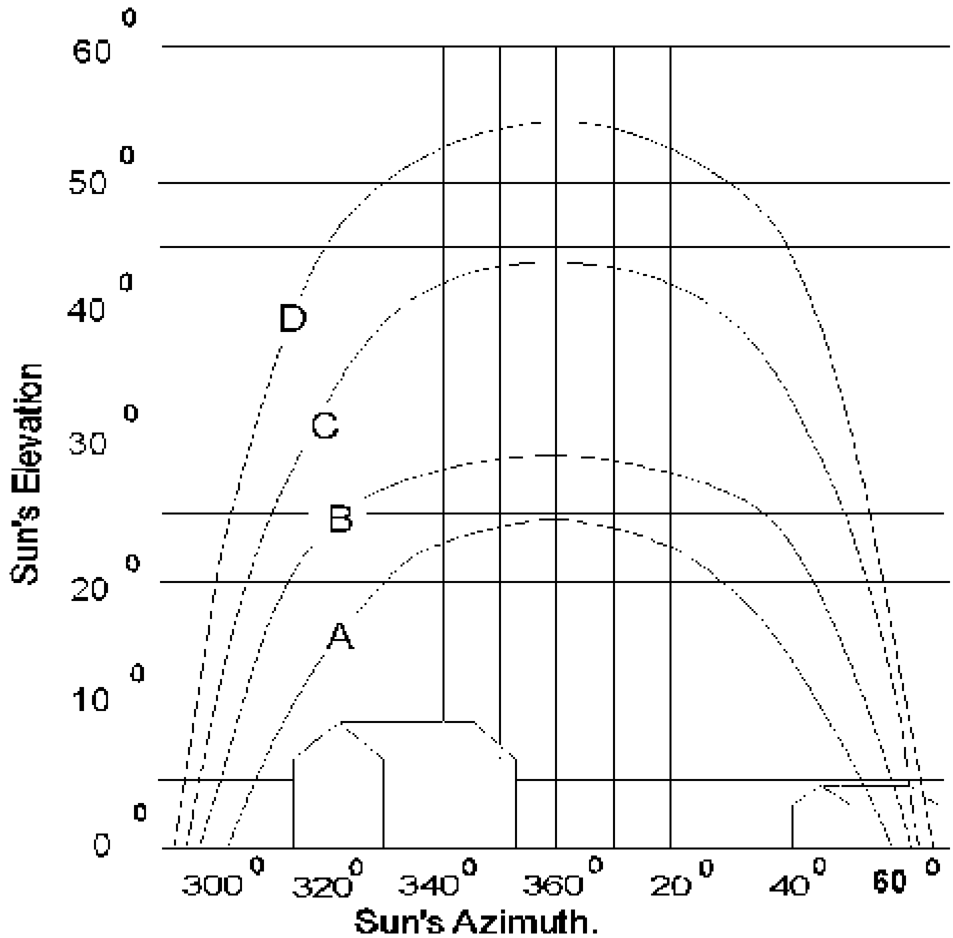


Figure 3.17.1 Exposure diagram for solar radiation instruments in the Southern Hemisphere.

3.18 Sunshine Duration.

3.18.1 The general site requirements for a sunshine recorder whether it is of the old Campbell Stokes type or a solid state sensor are the same as for solar radiation equipment.



Curve:

A = 40 S Latitude. C = 20 S Latitude

B = 30 S Latitude. D = 10 S Latitude.

Figure 3.18.1 Variations in sun's elevation and azimuth.

3.18.2 The proximity of obstructions is not as crucial as for solar radiation equipment. For a site to be suitable, the elevation of the top of an obstruction, as viewed from the position of the recorder, must not exceed 5^{O} between:

3.18.2.1 230^{O} - 302^{O} and 58^{O} - 130^{O} azimuth at latitude 10^{O} - 40^{O} S

3.18.3 For azimuth between 294^{O} - 360^{O} - 66^{O}, the elevation of the top of an object must not exceed the sun's elevation indicated by the four curves A, B, C, D for latitudes 40^{O}S, 30^{O}S, 20^{O}S and 10^{O}S respectively, as indicated in Figure 3.18. 1. Intermediate latitudes limitations can be interpolated from the diagram.

3.18.4 For stations between 45^{O} S and 67.5^{O} S, no obstructions should rise above 5^{O} in any direction, and for stations south of 67.5^{O} S, no obstruction should rise above 3^{O} in any direction.

3.19 DigiCORA.

3.19.1 DigiCORA upper air systems rely on OMEGA and VLF navaid and communications signals in Australia’s sphere of operations. LORAN-C networks are not available for calculating upper winds.

3.19.2 The geographical location being considered must first be checked using the H.O. Networks and Measurements Section's Omega/VLF Station Great Circle Projection software. This program will identify the geometry of the signal paths from the location under investigation to the remote Omega and VLF stations. There must be a minimum of one station in each of four quadrants around the station for which the OMEGA signal is reliably received, ideally spaced at 90^{O} to one another, although directional separations down to around 60^{O} appear acceptable. None of the signal paths from the four orthogonal stations should cross the Antarctic ice cap.

3.19.3 The site should not be within 150 km of a VLF or OMEGA station, and should not suffer radio interference in the bands near 10.2, 11.3 and 13.6 kHz. If the Navy communications VLF signals need to be used, there should also be no interference in the bands near 16.0, 17.4, 21.4, 22.3, 23.4, 24.4, 24.8 and 28.5 kHz. A background radio frequency spectrum analysis should be prepared, covering different times of day and over as long a period as is practical.

3.19.4 OMEGA stations greater than 10,000 km from the site tend to be unreliably received and should be discounted from siting considerations.

4 Radar and Remote Sensing Equipment.

4.1 WindFind Radar

4.1.1 In many instances, the Bureau of Meteorology uses radar for both wind find and weather watch purposes. The siting requirements for weather watch are more exacting than for wind find, so they could well prove the determining factor for a radar with a dual role.

4.1.2 The site for a wind find radar should be on a low hill or rise with the horizon as free from obstructions as possible. There should be no extensive obstructions, subtending an azimuth exceeding 4^{O} at the observation point. A symmetrical hill with a downward slope of approximately 6^{O} for a distance of 400 metres, in a hollow surrounded by hills rising to no more than 1^{O} or 2^{O} elevation would be ideal. This would eliminate ground echoes from beyond a short range.

4.1.3 No obstructions, including hills or mountains in the middle distance, should rise above an angle of 4^{O} elevation, as measured from the radar head. This is to remove errors caused by the radar locking onto distant hills for brief periods when the balloon is at a long range with an azimuth and elevation approaching that of the obstruction.

4.1.4 There should be no objects with large flat surfaces within a radius of 500 metres that may produce irregular side lobe reflections.

4.1.5 The radar needs to be in close proximity to the balloon launch facility to enable rapid lock-on to the balloon's radar target. In practice, many wind find radar can be installed on top of the observing building or on an adjoining low tower.

4.2 Weather Watch Radar

4.2.1 General.

4.2.1.1 The Bureau's S-Band and C-Band radar have beam widths from 0.9° (WSR 74C) to 3° (WF44). Limitations in the electronics preclude these radars from taking meaningful measurements within the first 5 km, so radar information from adjacent to the radar site itself will not be available.

4.2.1.2 Basic criteria for the selection of a site for weather watch radar are:

4.2.1.2.1 Good radar coverage of :
4.2.1.2.1.1 Areas where quantitative measurements will be most useful and/or
4.2.1.2.1.2 Areas where severe weather (thunderstorms, tropical cyclones, cold fronts, etc) develop or require continuous tracking;
4.2.1.2.2 Good radar coverage of urban areas, airports, air routes, marine installations and industrial areas, bearing in mind the need for minimum

ground clutter;

4.2.1.2.3 Minimum area affected by permanent echoes;

4.2.1.2.4 A site free from radio frequency interference;

4.2.1.2.5 Acceptance by local planning authorities; and

4.2.1.2.6 Reasonable access and availability of required infrastructural support facilities, particularly a high bandwidth communications link.

4.2.1.2.7 No danger to people in area.

4.2.1.2.8 Reasonale confidence in site not being built out.

4.2.1.3 Good radar coverage is said to be a skyline within which obstructions in sectors of interest do not exceed 0.5^{O} in elevation, except for obstructions subtending less than 1^{O} in azimuth.

4.2.1.4 As with all sites, the expected impact of future developments near the site must be considered.

4.2.1.5 Access to the site in bad weather is important to ensure outages are minimised.

4.2.2 Quantitative precipitation / Hydrological purposes

4.2.2.1 Radar which are to be used to provide quantitative precipitation estimates (QPE) have specific siting requirements. The techniques required to provide QPE normally require spatial resolutions of 2 km or less, although valuable information may still be obtained from coarser resolutions. As a rough guide, for optimum results, the effective range of the radar is therefore limited according to its beam width, being approximately:

1^{O} beam width........... 115 km

2^{O} beam width........... 57 km

3^{O} beam width........... 38 km.

The operational range of the radar will often extend well beyond these limits, but the absolute accuracy of the information decreases with distance. Figure 4.2.2.1 illustrates the dependence of accuracy of radar measurement of areal rainfall on distance from the radar site. It should be stressed that there are numerous corrections and assumptions inherent in this relationship and it must be considered as very approximate. The figure represents the optimal situation which is difficult to achieve in practice.

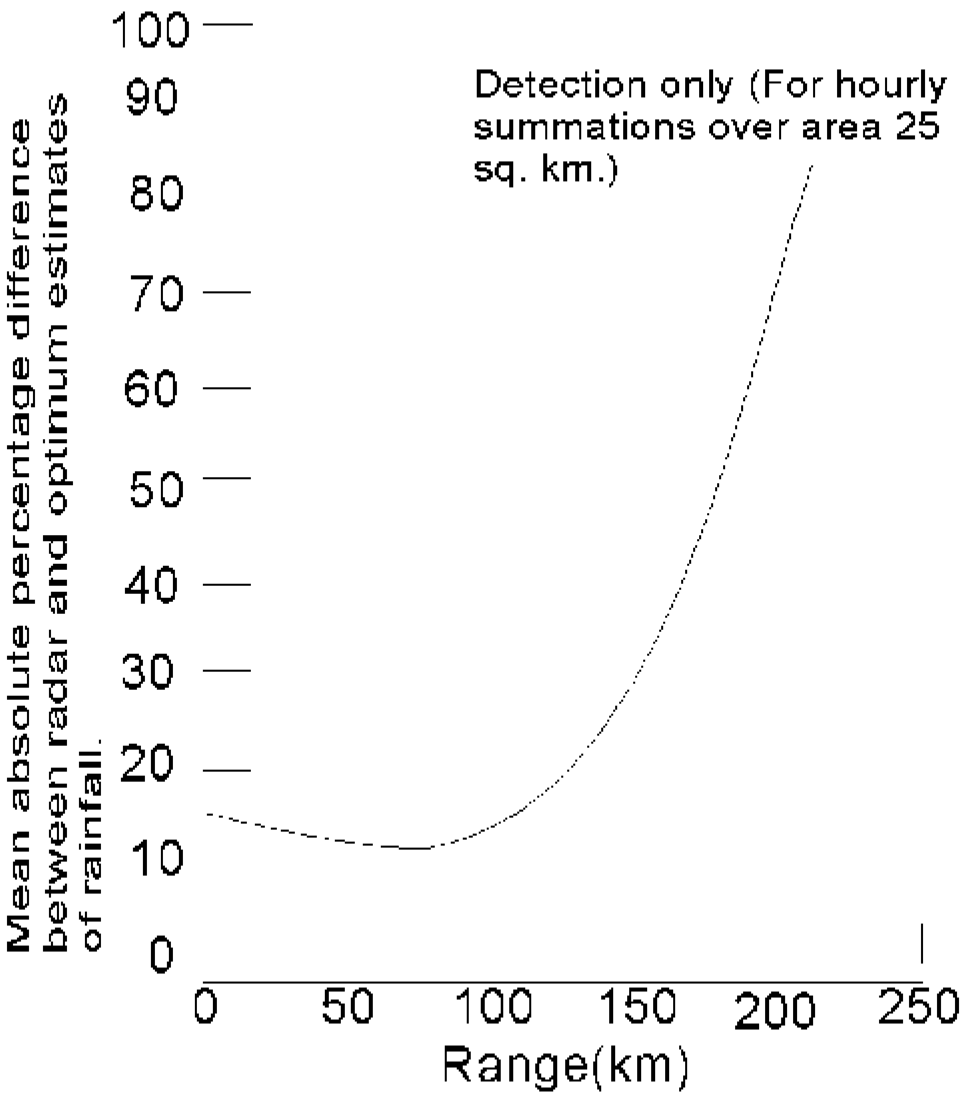


Figure 4.2.2.1 Dependence of accuracy of radar measurements of areal rainfall on distance from the radar site in an optimal situation (1^0 beamwidth - WMO 1972, 1978 sup.)

4.2.2.2 The radar needs to have an unobstructed view of the entire catchments requiring the QPE with the minimum radar horizon of 0.5^O in the directions of interest. Low beam elevations are required in order to obtain a good view of rain close to the ground for greater accuracy. The ground clutter needs to be kept to a minimum as the clutter significantly degrades the reliability of the precipitation estimates. The site chosen should not be elevated more than is absolutely necessary.

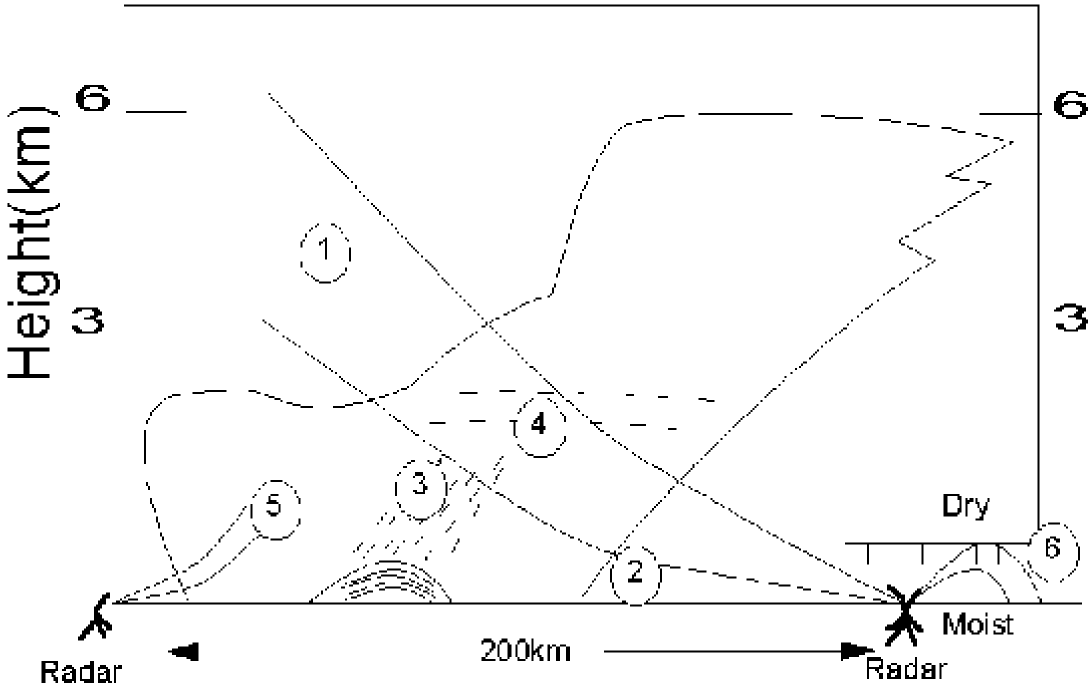


Figure 4.2.2.2 Cross-section through an area of frontal precipitation illustrating six sources of error in the radar measurement of surface rainfall intensity, namely (1) radar beam overshooting the shallow precipitation at long ranges, (2) low-level evaporation below the radar beam, (3) orographic enhancement above hills which goes undetected beneath the radar beam, (4) anomalously high radar signals from melting snow (the bright band), (5) under estimation of the intensity of drizzle because of the absence of large droplets, and (6) radar beam bending in the presence of a strong hydrolapse, causing it to intercept land or sea (Collinge, Kirby 1987).

4.2.2.3 Accurate QPE ideally require provision of suitable ground truthing to a surface rain gauge network, preferably a real-time reporting network. The radar should be located so as to maximise its view of the calibrating rain gauge network, which must be distributed relatively evenly throughout the area of interest and itself correctly sited.

4.2.2.4 S-Band radars have fewer siting considerations for QPE than C-Band due to the problems of attenuation with C-Band radar at higher rainfall rates (50 mm/hr or higher) and by hail. For C-Band radar, a detailed study of thunderstorm echo structure for the catchments must be made. It may be necessary to site the radar closer to or within the catchment in many cases. The meteorological situations which are likely to produce significant rainfall events need to be understood when selecting the site for and the type/beam width of the radar. Figure 4.2.2.2, (from Collinge, Kirby 1987) illustrates some of the meteorological considerations.

4.2.3 TAST Radar.

4.2.3.1 The purpose of Terminal Area Severe Thunderstorm (TAST) Radars are to identify hazards to aviation within a maximum radius of 110 kilometres of an airport.

4.2.3.2 The most critical areas for aviation are the final approach and departure corridors for each runway below 500 metres above ground level, as aircraft are vulnerable to severe down drafts, microbursts, turbulence etc. at these altitudes. The radar therefore needs to have a horizon elevation of 0.5^{O} or less in these directions, and no worse than 1.0^{O} in other directions.

4.2.3.3 The current operational mode of the TAST radar utilises sweep elevations extending up to about 10'. This effectively creates a blind zone above the radar extending out to a range of approximately 5.7 kilometres at 1000 metres above the level of the radar, and to 17 kilometres at 3000 metres.

4.2.3.4 The radar would ideally be located between 15 kilometres and 25 kilometres from the airport (closer to 15 kilometres if the radar is C-Band, due to potential attenuation problems in severe weather). The absolute limits would be no closer closer than 10 kilometres and no further than 50 kilometres. The radar should also have an unobstructed view of all approach paths to the airport (i.e. it should not lie beneath the approach paths).

4.2.3.5 The ground clutter in the areas of most interest must be minimised.

4.2.3.6 The radar should lie downstream of the directions from which severe storms typically approach the airport, however if the radar is C-Band, its location should be perpendicular to these directions, to minimise excessive attenuation from storm cells.

4.2.4 Doppler Weather Radar.

4.2.4.1 An important application of doppler weather radar is for the determination of the radial wind speed field in the area of interest, typically the final approach and departure corridors of an airport. The radar, therefore, must be sited so as to maximise the probability of detection of the variations in the wind field which may be hazardous to aviation.

4.2.4.2 If the radar is to detect the initial onset of microburst events, the radar may need to scan up to the level of the cloud base of middle level cloud (around 14, 000 feet) . This will maximise the warning lead time to aviation. For broader scale horizontal and vertical wind shear, the scan elevation may not need to be as high.

4.2.4.3 The scale of the wind speed field to be observed will determine the useful range of the radar, and hence its optimum location. Normally this maximum range is between 50 and 100 kilometres. Ambiguities develop in doppler radar returns much beyond 100 kilometres in range, although this does depend upon the pulse repetition frequency and velocity range being used. These ambiguities can only be removed with a corresponding loss in accuracy.

4.2.4.4 Doppler radar are not as susceptible to ground clutter as conventional radar. However, the site selected should still attempt to minimise this interference.

4.2.4.5 As doppler radar only detects the radial component of the wind field, attention should be given to the climatology of severe wind shear events (and microburst events) to reduce the chance of significant wind shear events being under-detected should the greatest shear occur tangential to the radar beam.

4.2.4.6 Most other general siting requirements for radar are applicable for doppler radar.

4.2.5 Broad-scale Weather Watch / Tropical Cyclone Watch.

4.2.5.1 If the radar's primary purpose is to maintain a weather watch over as great an area as possible, such as for tropical cyclone watch purposes, some siting considerations alter.

4.2.5.2 It is preferable to find a more elevated location with an uninterrupted view of the horizon at elevations close to 0^0 particularly over the sea. Ground clutter and anomalous propagation from the sea will increase, but this is an unavoidable trade-off for the increased range. However, if a low elevation site exists where the radar horizon would occur at 0^0, then this should be chosen over a more elevated site. In any case, radar towers should be just high enough to provide minimum clearance of nearby obstacles.

4.3 Wind Profiler.

4.3.1 Wind profilers are essentially vertically pointing radar that detect the doppler shift of atmospherically reflected radiowaves in order to determine wind velocity.

4.3.2 Profilers generally operate in three frequency bands:

Layer	Frequency range
Boundary (0 to 6 km)	around 900 to 1200 Mhz
Troposphere/Stratosphere (0 to 200 km)	around 400 to 450 Mhz
Stratosphere/Mesosphere (0 to 100 km)	around 40 to 60 Mhz.

Other frequency and height combinations can also be used for specific applications, generally of a research nature, such as the use of a 50 MHz profiler for boundary layer studies in precipitation.

4.3.3 The size of the antenna increases with decreasing frequency and imposes limitations on the types of site available. For example,a 950 MHz profiler may fit on the back of a trailer, whila a 50 MHz profiler may cover an area of approx 100 m x 100 m. while. With the size of the antenna in mind, the points in the following paragraphs should be considered.

4.3.4 The profilers should be sited away from any radio source operating near its frequency, be it a transmitter or a radio noise generating system. The profiler should be located away from installations which may be adversely affected by the side-lobes of the profiler.

4.3.5 The profiler is best located in a depression, a sharp valley or, ideally, a steep sided disused quarry that reduces the antenna side lobes. Care needs to be taken to ensure that the site is not prone to flooding. Alternately, a level site where a RF fence can be installed can be selected, as the RF fence must be horizontal to minimise reflections at oblique angles.

4.3.6 Although reflected signals from the sea and mountain ranges that lie at distances from the profiler that are equivalent to the range of the profiler can be eliminated during signal processing, it is best to select a site where RF reflections of side lobes from these sources is minimised.

4.3.7 Profilers should also not be located directly below air routes, as signals reflected from aircraft can swamp the receiver electronics, leading to data losses.

4.4 Lidar.

4.4.1 Lidar are typically used in a scanning mode, similar to radar, and can be used for detailed analysis of clouds, pollution, turbulence, aerosols and water vapour.

4.4.2 General siting requirements are similar to radar if a full hemispheric coverage is required. However, specific applications can allow use of lidar in areas with far more restricted horizons.

4.4.3 Care must be taken to ensure the safety to human eyesight when using a lidar. Approval from the local authorities will be necessary for any site selected before a lidar can be used.

4.5 RASS.

4.5.1 Radio Acoustic Sounding Systems (RASS) are typically installed in conjunction with a wind profiler. The RASS permits continuous monitoring of the virtual temperature profile through the boundary layer.

4.5.2 The principle requirement is to select a site free of noise which may interfere with the operation of the unit. Conversely, the site selected must not interfere with other activities in surrounding areas. Generally, if the site is suitable for a wind profiler, it stands a good chance of also being suitable for a RASS.

5 Ozone Monitoring Equipment.

5.1 Dobson Spectrophotometer (ozone).

5.1.1 The Dobson spectrophotometer's requirements are essentially the same as for sunshine measuring instruments. It requires a stable platform with ideally an unobstructed full 360^0 exposure to the sky. A clear sky for solar zenith angle 80^0 from the vertical along the solar path must be considered the minimum requirement. A horizon obstruction diagram (skyline survey) needs to be prepared from the position where the spectrophotometer is to be operated.

5.1.2 A sloping ramp into the storage room is an advantage and the storage room should be protected from extremes of heat and cold.

5.2 Ozone Sonde.

5.2.1 Most requirements of the ozone sonde are the same as for conventional radiosondes. However, the balloon filling facility (building or remote launcher) must be large enough to house 2000 gram balloons. If a building is to be used, the availability of dual doors is essential.

6 Marine Equipment.

6.1 Tide Gauge.

6.1.1 The site for a tide gauge needs to be selected in accordance with the purposes for which the data are to be used. The Bureau's interests concern the monitoring of sea level for greenhouse research purposes (tied in with the WMO - IOC GLOSS project), for ascertaining the slope of ocean surfaces to deduce ocean current structure and for the forecasting and monitoring of weather caused storm surges. Tsunami detection is not currently the Bureaus responsibility.

6.1.2 The tide gauge should be installed in conjunction with an automatic weather station so that simultaneous monitoring of meteorological elements can be achieved, in almost all instances.

6.1.3 For long term climatically induced sea level changes, special considerations apply, as outlined in the following sections:

6.1.3.1 Gauges for this purpose require a site as free from local perturbations in the tide as possible from both bathometric and meteorological influences. The bathometry of the ocean floor should be relatively featureless to the edge of the continental shelf and unlikely to be affected from natural or man-made sources.

6.1.3.2 The site should be selected on a relatively featureless (i.e. no major bays, headlands or river mouths within approximately 50 km) stretch of coastline to increase its representativeness. The tide gauge also needs protection from the open sea, such as that afforded by a breakwater, but should not be located in an inner harbour area where very localised effects (e.g. tunnelling of the wind up narrow waterways) may influence the gauge's readings.

6.1.3.3 The site should be geologically stable, with the minimum likelihood of subsidence. Ideally, the gauge would be mounted on a concrete pillar fixed to bedrock, although this is liable to be economically unfeasible. The site must, however, be of high stability with the underlying structure unlikely to sink into the sea bed with time.

6.1.3.4 The site needs to be surveyed to the first order, with an elevation accuracy of as close to +/- 1 mm as possible. Permanent survey datum points should be installed along the coast on geologically stable ground for the purpose of cross referencing the gauge to detect movements of the tide gauge's survey datum point. These datum points, in turn, should be tied to the Australian Geodetic Grid.

6.1.4 Storm Surges.

6.1.4.1 These tide gauges need to be sited at a location representative of the area for which storm surge information is required. This may be at the head of a funnel shaped bay, or on an offshore island to provide advance warning. The site must be sufficiently high above sea level that neither it nor its power or communication facilities will be rendered inoperative by the highest possible storm surge.

6.1.4.2 The tide gauge site requirements are less stringent than for a long term sea level monitoring installation. However, the gauge still should avoid very local influences on the sea level and should be installed on a stable platform. The gauge should be referenced to the Australian Geodetic Grid, if possible, with a survey accuracy of approximately 1 cm.

6.1.5 Ocean Surface Slope.

6.1.5.1 Tide gauges designed to detect variations of ocean surface slope should be mounted at a site representative of the open ocean. Otherwise, the requirements are the same as for a storm surge monitoring gauge.

6.2 Wave Rider and Shallow Ocean Moored Buoys.

6.2.1 The primary determinant for the selection of a site for a shallow ocean or moored buoy is defined by the parameters the buoy is measuring and the area for which the readings are to relate. For the Bureau's purposes, normally, the buoy will be required to measure the deep ocean sea state. For many applications users tend to be interested in location specific sea state information. The latter case largely identifies the site by itself.

6.2.2 For deep ocean sea state measurements, the bathometry of the fetches produce the seas and swell that are of interest need to be checked to ensure there are no shoals or reefs that will alter the measured wave heights. Care needs to be taken to ensure that the site selected is not prone to local refraction or diffraction effects caused by coastal features, particularly if the buoy measures directional wave spectra. In general, an open ocean site which has water at least 100 metres deep in all directions of interest over fetches of at least 100 kilometres should be chosen. Sites near islands, sand banks and reef complexes should be avoided. If a shallower site is selected, care must be taken to ensure that the site will not be so shallow as to be affected by shallow water breakers in extreme weather situations.

6.2.3 The ocean floor where the mooring is to be located must be stable and free from chasms and pinnacles. Sloping sites should be avoided as these may be prone to mud slides. If a shallow site is chosen, the site should be free from coral.

6.2.4 There are other considerations which need to be borne in mind, including: distance limitations imposed if radio communications are to be used; limitations or restrictions imposed by port and/or marine authorities; need to avoid areas where fishing trawlers operate; access for maintenance and initial deployment; ability to track and collect the buoy, should it break free; as the physical limitations imposed by the length of the mooring and the environmental tolerances of the buoy.

6.3 Deep Ocean Moored Buoys.

6.3.1 Deep ocean moored buoys are very expensive instruments, so it is important that the investment is well protected.

6.3.2 Most of the considerations for shallow ocean buoys apply to the deep ocean buoys. Deep ocean buoys generally can be moored in waters between 2 and 5 kilometres deep, to keep the mooring short enough to be economically realistic but deep enough to avoid bottom trawling activities. This depth range should make it possible to install a buoy on oceanic ridges in otherwise very deep oceanic basins.

6.3.3 Locations to one side of the major shipping routes should be chosen to reduce the chance of collision. However, it is advantageous to be reasonably close to the routes in case the buoy breaks free. Oceanic areas where the surface currents are likely to sweep the buoy towards the coast, should it break free, are preferred as this greatly increases the chance of recovery of the buoy.

7 Hydrological Equipment.

7.1 Hydrological Equipment.

7.1.1 In most respects the siting and exposure of instrumentation and equipment for hydrological applications should conform to the general siting guidelines for meteorological instruments and facilities. However, for many applications, access to the site during the wet season or floods assumes a greater importance than for other instrumentation, so this factor will have to be given greater consideration when selecting sites. WMO No 324 (Casebook on Hydrological Network Design Practice) provides guidance which covers a wide range of hydrological problems that may be encountered and should be referred to for greater detail.

7.2 Rainfall Measurements.

7.2.1 The measurement of rainfall for hydrological applications has similar requirements to the requirements for other applications, and hence the siting and exposure considerations outlined in 3.8 should be observed.

7.2.2 The application of rapid response rainfall measurements to the warning of flash floods imposes additional constraints on the siting of tipping bucket rain gauges for this purpose. The geometry of the catchment and the requirement for real time telemetry of the rainfall data on an event basis have lead to the development of the ALERT system with the TBRG on the top of a cylindrical pipe along with a Yagi or omni directional antenna. This configuration clearly adversely affects the accuracy of the rainfall measurements. However, provided the data are being used for no other application and the inherent inaccuracies of the data are acknowledged by the users of the system, this configuration can be accepted where correct exposure of the TBRG is difficult to achieve.

7.3 River height Measurements

7.3.1 The Bureau is not involved with the measurement of water discharge for the rivers it studies and hence discussion will be confined to the measurement of river height (or stage). When selecting a site for installation of a river height gauge, or even for the positioning of manually read river height staffs, it is important to ensure the observations can be made accurately and that the stability of the stream channel is high.

7.3.2 The following points should be considered when selecting river stage site:

7.3.2.1 The site should be easily accessible by the observer in a flood situation. The same considerations apply to automated gauges, for maintenance purposes.

7.3.2.2 The site should be away from the confluence of tributary streams so as to avoid backwater effects from the tributary on the station.

7.3.2.3 The stages should not be affected by any unrepresentative influences such as those associated with hydroelectricity generation, industrial intakes and outfalls.

7.3.2.4 Sites should be just upstream of natural falls, riffle or artificial control structures. This location is particularly suitable if the downstream level variations do not affect the discharge over the structure.

7.3.2.5 Gauges should be located where the channel bed is regular and stable. This should also exclude river delta areas, multiple channels in a river, river beds with excessive sediment or movable boulders, and rivers in areas subject to blockages from fallen trees and similar obstructions. If this is not possible, frequent reviews of the river cross-section must be made.

7.3.2.6 The site should preferably be in a straight reach of the river where representative measurements can be made.

7.3.2.7 The site should be relatively flat to reduce the likelihood of damage from moving boulders and floating debris.

7.3.3 In intermittent water courses, the gauge employed must be at the lowest point of the river bed to allow measurement of the lowest river flows.

7.3.4 For stations which use a radio communications link, site selection should also consider the number of repeater stations required to relay the information back to the base station.

7.3.5 In regions where it snows, it is advisable to locate river height gauges sufficiently far downstream to avoid areas where the river freezes over. Alternatively, special techniques must be used to avoid freezing of the gauge (WMO 1972).

7.4 ALERT AWS.

7.4.1 The siting and exposure of other sensors attached to an ALERT system should conform to the requirements stipulated in the relevant sections of this specification. It is unlikely that the site used for river height gauging will be particularly suitable.

7.5 ALERT repeater Station.

7.5.1 ALERT repeater stations generally require a near line of sight view of the field stations. This makes elevated stations desirable. Radio path surveys should be conducted under different atmospheric conditions to ensure reliable transmission of data from the field stations to the base station can be achieved.

7.5.2 Care is to be taken to ensure that radio interference from other sources is avoided.

Attachment 1.

Summarised guidelines.

A1 Purpose

A1.1 This summary specifies the key siting and exposure requirements for meteorological instruments and equipment under normal circumstances. Explanations for these requirements and greater detail to allow informed decisions to be made at difficult locations is contained in the main document.

A2 Facilities.

A2.1 Bureau Observing Offices at Airports.

A2.1.1 Primary information.

A2.2 Co-operative Observing Stations and Automatic Weather Stations.

A2.2.1 Primary Information

A2.3 Reference Climate Stations.

A2.3.1 Primary Information.

A2.4 Special Purpose Stations.

A2.4.1 Primary information.

A2.5 BAPMoN Stations.

A2.5.1 Primary information.

A2.6 Upper Air Facilities.

A2.6.1 Hydrogen Generation and Balloon Filling Facilities.

A2.6.1.1 Balloon Filling Room Door orientation: perpendicular to the prevailing 10 metre wind direction (5 m/s or more) at the station.

A2.6.1.2 Clear zone within 90 metres of doors, then nothing protruding above a 1:5 slope.

A2.6.2 Remote Balloon Launcher.

A2.6.2.1 Obstruction free area -

A2.6.2.1.1 *optimum :* 40 metres minimum in all directions.

A2.6.2.1.2 *acceptable* : no obstructions above an angle of 4^{O} (slope 1:14) apart from in a 5^{O} sector (prevailing wind occurrence <5%) where obstructions may extend to 8^{O}.

A2.6.2.2 Clear area (buffer area): minimum of 40 metres in all directions.

A2.6.2.3 Antarctic and exposed south coastal areas (wind speed > 20 m/s) - obstruction free angle: 2^{O} in the sectors towards which the prevailing wind blows.

A2.6.3 Theodolite Platform.

A2.6.3.1 Exposure : sky visible above 4^{O} elevation in all directions.

A2.6.3.2 Position : within 50 metres of hydrogen generation shelter, outside clear zones and buffer areas, 24 hour all weather access, and away from bright lights.

A3 Instruments.

A3.1 Instrumentation at Airports.

A3.1.1 General : representative of the airport and does not infringe obstacle limitation surfaces.

A3.1.2 Instrument enclosures separation distances:

A3.1.2.1	Turning areas and aprons	80 m
A3.1.2.2	Runways	60 m
A3.1.2.3	Taxiways	30 m

A3.2 Automatic Weather Stations.

A3.2.1	Component instruments :	as per individual siting guidelines
	AWS electronics:	outside southern side of enclosure.
	Greatest box dimension:	not to exceed 1 metre.

A3.2.2 Barometer -

A3.2.2.1	Bureau staffed location :	barometer located in office.
A3.2.2.2	Remote AWS:	mounted in the AWS 300 mm above base.
A3.2.2.3	Non-Bureau staffed airport :	AWS barometer located either in AWS, or in observation office, depending on individual requirements.

A3.3 Pressure Sensors.

A3.3.1 Pressure - Airports :	as near to ARP as is practicable.
A3.3.2 Survey accuracy :	Elevation to 10 cm, cross referenced to ARP and the Australian National Geodetic Grid.
A3.3.3 Location :	no wind effects, direct solar radiation, vibrations, localised heating or cooling.

A3.4 Instrument Enclosure.

A3.4.1 Standard :	17 metre square, centred in a 30 metre square buffer zone aligned true North - South.
A3.4.2 Non-standard :	level, clearly defined with natural vegetation trimmed to a few centimetres. No concrete or asphalt walkways wider than 0.5 metres.
A3.4.3 Buffer area :	natural vegetation trimmed below 0.5 metres.
A3.4.4 Exposure :	*isolated obstructions* (<15 metres high) below a slope of 1:4; or *obstructions* (>15 metres high or cover >45^{O} azimuth) below a slope of 1:10.

A3.5 Anemometers.

A3.5.1 Standard height :	10 metres above mean ground level.

A3.5.2 Exposure-

A3.5.2.1 WMO Standard : Level site, obstruction free slope 1:10.

Optimum : Level site, obstruction free slope 1:30.

Extensive obstructions : 10 metres above the effective height of obstructions.

A3.5.2.2 Isolated obstructions:

A3.5.2.2.1 *12 metres* or more in height.

Distance to Obstruction.	Minimum height of Anemometer.
h	1.75 h
5 h	1.67 h
10 h	1.50 h
20 h	1.25 h
25 h	1.13 h
30 h	1.00 h

Where h = obstruction height.

A3.5.2.2.2 up to *10 metres* in height :

Obstruction Height (h)	Factor	Min. distance to Anemometer (10m AGL)
4 m	x 10 h	40 m
6 m	x 10 h	60 m
7 m	x 10 h	70 m
8 m	x 20 h	160 m
9 m	x 28 h	250 m
10 m	x 30 h	300 m

A3.5.2.2.3 *10-12m high* obstructions subtending angles >10° separation distance 350m.

A3.5.2.2.4 *thin obstructions* : 30 times their half-width.

A3.5.2.3 Clearances on airports:

A3.5.2.3.1	Turning areas and aprons	150 metres
A3.5.2.3.2	Runways	120 metres
A3.5.2.3.3	Taxiways	75 metres

A3.6 Instrument Shelter.

A3.6.1 Shelter position : base 1.1 metres above the ground, oriented true north/south.

A3.6.2 General : level area, trimmed natural vegetation not shielded by obstructions or close to extensive areas of concrete, asphalt, rock, etc.

A3.6.3 Min. clearance : 5 times the width of any unrepresentative surface.

A3.7 Terrestrial Minimum and Soil Temperature Thermometers.

A3.7.1 Siting requirements :

A3.7.1.1 Level plot of bare ground 1.8m square;

A3.7.1.2 No shadows cast by other instruments while the elevation of the sun is 3^{O} or greater above the horizon;

A3.8 Precipitation Gauges.

A3.8.1 Gauge orifice 300 mm above ground level.

A3.8.2 Uniformly sheltered site, but no obstructions closer protruding through a slope of 1:2 (optimum uniform clearance 1:4).

A3.8.3 Surrounding surface (within 1 metre): short grass, or a semiporous, slightly irregular natural covering. Avoid hard, flat surfaces, such as concrete, asphalt and rock.

A3.8.4 Snow :

A3.8.4.1 Sheltered site with mean wind speed seldom > 15 m/s.

A3.8.4.2 Use a Tretyakov-type wind shield and a Valdai double fence.

A3.8.4.3 Gauge height above ground 2 metres or above highest snow level.

A3.8.5 Optical rain gauges: on poles above splash zone and obstructions. Typically 1.5m above the ground.

A3.9 Present Weather Sensors.

A3.9.1 Representative area : Avoid hollows. 1.5 metres above ground.

A3.10 Evaporation Pans.

A3.10.1 Site with surface airflow representative of region of interest.

A3.10.2 Hilly or mountainous terrain: site on a plateau or level area.

A3.10.3 General :

A3.10.3.1 No obstructions which shadow the pan with sun elevation > 3^{O}.
A3.10.3.2 Surrounding ground level with trimmed natural vegetative cover
A3.10.3.3 No concrete, rock, asphalt,etc.
A3.10.3.4 Obstacle clearance distance: minimum of 10 times (optimum 30 times) height of obstruction.
A3.10.3.5 Minimum 1.5 metres (preferably 2.5 metres) from any instrument higher than pan.
A3.10.3.6 No chemical contamination or excessive fallen leaves and twigs.

A3.11 Ceilometers.

A3.11.1 Obstruction free zone immediately overhead.

A3.11.2 Site on level ground or a slight rise, free from smoke and industrial air pollution.
A3.11.3 Geometric centre of airfield (1 unit) or middle markers (multiple units).

A3.12 Cloud Base Searchlight.

A3.12.1 Baseline 150m (100m absolute minimum).

A3.12.2 Observing point < 15 metres from observer's office.

A3.12.3 From observing point, sky visible at elevations:

A3.12.3.1 Between 10^{O} and 90^{O} when facing towards the light;
and
Between 90^{O} and 60^{O} when facing away from the light.

A3.12.4 The area free from any lights close to the fields of view set out in 3.12.3.1. above.

A3.13 Runway Visual Range (RVR) Equipment (including background luminance meter).

A3.13.1 Locations : touchdown zones (300m from threshold) and mid-point of runways.

A3.13.2 Within 120 metres laterally from the centre of the runway.

A3.13.3 Height : between 2 and 3 metres above ground.

A3.13.4 Background luminance sensor: For mid-latitude locations in Australia, sensor monitors the southern sky at an elevation of approximately 45^{O} at a location slightly away from the runway.

A3.14 Visibility Meters.

A3.14.1 Site : geometric centre of the area of interest, avoiding fog prone hollows, remote from all large obstructions.

A3.14.2 For multiple units, as per RVR equipment.

A3.15 Video Surveillance Cameras.

A3.15.1 Site : unobstructed view of the horizon in all directions, not adjacent to strong lighting.

A3.16 Lightning / Thunderstorm Detection Systems.

A3.16.1 Remote antennae particularly for directional systems :open areas free from metal structures, power transmission lines or rough terrain.

A3.16.2 Time-of-arrival technique sensors :less susceptible to site induced inaccuracies, but open areas preferred.

A3.16.3 Lightning stroke counter :open site free from human caused electrical discharges.

A3.17 Solar Radiation.

A3.17.1 Refer to figures in the main document.

A3.18 Sunshine Duration.

A3.18.1 For latitudes < 45 ^{o}
obstruction elevations must not exceed 5^{O} between 230^{O} - 302^{O} and 58 ^{O} - 130^{O} azimuth.

A3.18.2 For azimuth between 294 ^{O} - 360 ^{O} - 066 ^{O} , refer to figure 3.18.1 (page 50 in main document).

A3.18.3 For stations between 45^{O}S and 67.5 ^{O}S, no obstructions above 5 ^{O} in any direction.

A3.18.4 For stations south of 67.5^{O}S, no obstructions above 3^{O} in any direction.

A3.19 DigiCORA.

A3.19.1 A minimum of one reliably received OMEGA station in each of four quadrants around the DigiCORA, ideally spaced at 90^{O} to to one another (directional separations down to 60 ^{O} acceptable).

A3.19.2 No key signal paths should cross the Antarctic ice cap.

A3.19.3 Digicora operators should not select VLF or Omega stations that are within 150 km of there site.

A3.19.4 No radio interference in the bands near 10.2, 11.3 and 13.6 kHz (also 16.0, 17.4, 21.4, 22.3, 23.4, 24.4, 24.8 and 28.5 kHz if Navy VLF signals to be used).

A3.19.5 Do not rely on OMEGA stations > 10,000 km from the site.

A4 Radar and Remote Sensing Equipment.

A4.1 Wind Find Radar.

A4.1.1 No extensive obstructions above radar, subtending an angle exceeding four degrees at the observation point.

A4.1.2 No obstructions, including hills or mountains in the middle distance, above an angle of 4^{O} elevation

A4.1.3 No objects with large flat surfaces within a radius of 500 metres.

A4.1.4 Radar in close proximity to balloon launch facility.

A4.2 Weather Watch Radar.

A4.2.1 Siting conditional upon a multitude of factors. Refer to main document.

A4.3 Wind Profiler.

A4.3.1 Site :

A4.3.1.1 Away from any radio source operating near its frequency.

A4.3.1.2 Away from installations which may be adversely affected by side-lobes.

A4.3.1.3 Best located in a depression, a sharp valley or, ideally, a steep sided disused quarry.

A4.3.1.4 Sites where RF reflections of side lobes from sources within the profiler operating range is minimised.

A4.3.1.5 Not directly below air routes.

A4.4 Lidar.

A4.4.1 Similar to radar if full hemispheric coverage is required.

A4.4.2 Specific applications may allow far more restricted horizons.

A4.4.3 Use of Lidar on the site must not threaten the safety to human eyesight.

A4.5 RASS.

A4.5.1 Typically installed in conjunction with a wind profiler.

A4.5.2 Site must be free of noise which may interfere with the operation of the unit.

A4.5.3 Noise from the site selected must not interfere with other activities in surrounding areas.

A5 Ozone Monitoring Equipment.

A5.1 Dobson Spectrophotometer (ozone).

A5.1.1 Same as for sunshine measuring instruments.

Ideally : an unobstructed full 360^{O} exposure to the sky.

Minimum requirement : A clear sky for solar zenith angle 80^{O} from the vertical along the solar path.

A5.2 Ozone Sonde.

A5.2.1 As for conventional radiosondes, except balloon filling facility (building or remote launcher) must be large enough to house 2000 gram balloons. Dual doors essential for building facility.

A6 Marine Equipment.

A6.1 Tide Gauge.

A6.1.1 General : Sited in conjunction with an automatic weather station.

A6.1.2 Specific :

A6.1.2.1 *Long term climatically* induced sea level changes :

A6.1.2.1.1 site as free from local perturbations in the tide as possible from both bathometric and meteorological influences.
A6.1.2.1.2 site on a relatively featureless stretch of coastline.
A6.1.2.1.3 protected from the open sea, but not in an inner harbour area.
A6.1.2.1.4 geologically stable site.
A6.1.2.1.5 able to be surveyed to the first order.

A6.1.2.2 *Storm surges* :
A6.1.2.2.1 representative location for which storm surge information is required.
A6.1.2.2.2 site must not be rendered inoperative by the highest possible storm surge.
A6.1.2.2.3 site should avoid very local influences on the sea level.

A6.1.2.3 *Ocean surface slope* :
A6.1.2.3.1 site representative of the open ocean.
A6.1.2.3.2 other requirements as for storm surge monitoring.

A6.2 Wave Rider and Shallow Ocean Moored buoys.

A6.2.1 Site determined by parameters the buoy is to measure and their application.

A6.2.2 Deep ocean sea state measurements: Open ocean site with water at least 100 metres deep in all directions of interest over fetches of at least 100 kilometres preferred.

A6.2.3 Avoid sites near islands, sand banks and reef complexes.

A6.2.4 The ocean floor where the mooring is to be located must be geologically stable and free from chasms and pinnacles.

A6.2.5 Other considerations :

A6.2.5.1	distance limitations imposed if radio communications are to be used;
A6.2.5.2	limitations or restrictions imposed by port and/or marine authorities;
A6.2.5.3	need to avoid areas where fishing trawlers operate;
A6.2.5.4	access for maintenance and initial deployment;
A6.2.5.5	ability to track and collect the buoy, should it break free;
A6.2.5.6	the physical limitations imposed by the length of the mooring and the environmental tolerances of the buoy.

A6.3 Deep Ocean Moored Buoys.

A6.3.1 Generally can be moored in waters between 2 and 5 kilometres deep.

A6.3.2 Locations to one side of the major shipping routes preferred.

A6.3.3 Oceanic areas where surface currents are likely to sweep the buoy towards the coast are preferred.

A7 Hydrological Equipment.

A7.1 Hydrological Equipment.

A7.1.1 General requirements are as per meteorological requirements.

A7.1.2 Access to the site during the wet season or floods important.

A7.2 Rainfall Measurements.

A7.2.1 As per 3.8.

A7.2.2 Installation on top of poles only tolerable if essential to fulfil flood warning role and correct exposure cannot be achieved.

A7.3 River Height Measurements.

A7.3.1 Stage measurements:

A7.3.1.1	site away from the confluence of tributary streams.
A7.3.1.2	stages not affected by any unrepresentative influences such as those associated with hydro-electricity generation, industrial intakes and outfalls, etc.
A7.3.1.3	sites just upstream of natural falls, riffle or artificial control structure.
A7.3.1.4	channel bed regular and stable.
A7.3.1.5	site in a straight reach of the river.
A7.3.1.6	site should be relatively flat.

A7.3.2 Intermittent water courses: gauge at the lowest point of the river bed.

A7.4 ALERT AWS.

A7.4.1 As per meteorological AWS. Sites where river heights are measured are unlikely to be suitable.

A7.5 ALERT Repeater Station.

A7.5.1 Site: near line of sight view of the field stations.

Attachment 2 - WMO Accuracy Standards.

ACCURACY REQUIREMENTS FOR METEOROLOGICAL SURFACE MEASUREMENTS AND RELATED SENSOR PERFORMANCE CHARACTERS FOR AUTOMATIC WEATHER STATIONS.

(1)		(2)	(3)	(4)	(5)	(6)
Variable.		Range.	Reported resolution.	Mode of measurement/ observation.	Required accuracy.	Remarks.
1. Temperature.						
1.1	Air-temperature.	-60 - +60°C	0.1°C	I	±0.1°C	
1.2	Extremes.	-60 - +60°C	0.1°C	I	±0.5°C	
1.3	Sea-surface temperature.	-2 - +40°C	0.1°C	I	±0.1°C	
2. Humidity.						
2.1	Dewpoint.	<-60 - +35°C	0.1°C	I	±0.5°C	-If measured directly. -Tending to ±0.1°C when relative humidity nearing saturation.
2.2	Relative humidity	5 - 100%	1%	I	±3%	-If measured directly. -Tending to ±1% when relative humidity nearing saturation.
3. Atmospheric pressure.						
3.1	Pressure.	920 - 1080 hPa	0.1 hPa	I	±0.1 hPa	-Range to sea level.
3.2	Tendency.	Not specified.	0.1 hPa	I	±0.2 hPa	-Difference between instantaneous values.
4. Clouds.						
4.1	Cloud amount.	0 - 8/8	1/8	I	±1/8	
4.2	Height of cloud base.	<30m - 30km.	30m	I	±10m for #100m ±10% for>100m	
5. Wind.						
5.1	Speed.	0 - 75m/s	0.5m/s	A	±0.5m/s for #5m/s ±10% for>5m/s	-Average over 2 and/or 10 min.
5.2	Direction.	0 - 360°	10°	A	±5°	-Average over 2 and/or 10min.

ATTACHMENT 2.

(1)		(2)	(3)	(4)	(5)	(6)
Variable.		Range.	Reported resolution.	Mode of measurement/ observation.	Required accuracy.	Remarks.
5.3	Gusts	5 - 75m/s	0.5m/s	A	±10%	-Highest 3 sec. average.
6. Precipitation.						
6.1	Amount.	0 - >400mm	0.1mm	T	±0.1mm for #5mm ±2% for>5mm	
6.2	Depth of snow.	0 - 10m	1cm	A	±1cm for #20cm ±5% for>20cm	-Average depth over an area representative for the observing site.
6.3	Thickness of ice accretion on ships.	Not specified.	1cm	I	±1cm for #10cm ±10% for>10cm	
7. Radiation.						
7.1	Sunshine Duration	0 - 24 h	0.1 h	T	±0.1 h	
7.2	Net radiation.	Not specified.	1 $MJm^{2}d^{1}$	T	±0.4$MJm^{2}d^{1}$ for #8$MJm^{2}d^{1}$ ±5% for>8$MJm^{2}d^{1}$	
8. Visibility.						
8.1	M.O.R	<50m - 70km	50m	I	±50m for #50m ±10% for>500m	
8.2	R.V.R	50m - 1500m	25m	A	±25m for #150m ±50m for>150m - #500m ±100m for >500m - #1000m ±200m for>1000m	-Average over 1 min and 10 min..
9. Waves.						
9.1	Wave height.	0 - 30m	0.1m	A	±0.5m for #5m ±10% for>5m	-Average over 20 min for instrumental measurements.
9.2	Wave period.	0 - 100s	1s	A	±0.5s	-Average over 20 min for instrumental measurements.
9.3	Wave direction.	0 - 360°	10°	A	±10°	-Average over 20 min for instrumental measurements.
10. Evaporation.						

ATTACHMENT 2.

(1)		(2)	(3)	(4)	(5)	(6)
Variable.		Range.	Reported resolution.	Mode of measurement/ observation.	Required accuracy.	Remarks.
10.1	Amount of pan evaporation.	0 - 10mm	0.1mm	T	±0.1mm for #5mm ±2% for>5mm	

Source: World Meteorological Organization, Manual on Codes, WMO-No 306.

(1) Basic variable.
(2) Common range for most variables, limits depend on local climatological conditions.
(3) The most stringent resolution as determined by the *Manual on Codes* (WMO-No 306).
(4) I: Instantaneous — In order to exclude the natural small-scale variability and the noise, an average value over a period of one minute is considered as a minimum and most suitable; averages over periods, of up to 10 minutes are acceptable.
A: Averaging — Averaged values over a fixed time period as specified by the coding requirements.
T: Totals — Totals over a fixed time period(s), as specified by the coding requirements.
(5) Recommended accuracy requirements for general operational use. Individual applications may have less stringent requirements. The stated value of required accuracy represents the uncertainty of the reported value with respect to the true value and indicates the interval in which the true value lies with a stated probability. The recommended probability level 95 per cent, which corresponds to the 2 s level for a normal (Gaussian) distribution of the variable. The assumption that all known corrections are taken into account implies that the errors in reported values will have a mean value (or bias) close to zero. Any residual bias should be small compared with the stated accuracy requirement. The true value is that value which, under operational conditions, characterizes perfectly the variable to be measured/observed over the representative time, area and/or volume interval required, taking into account siting and exposure.

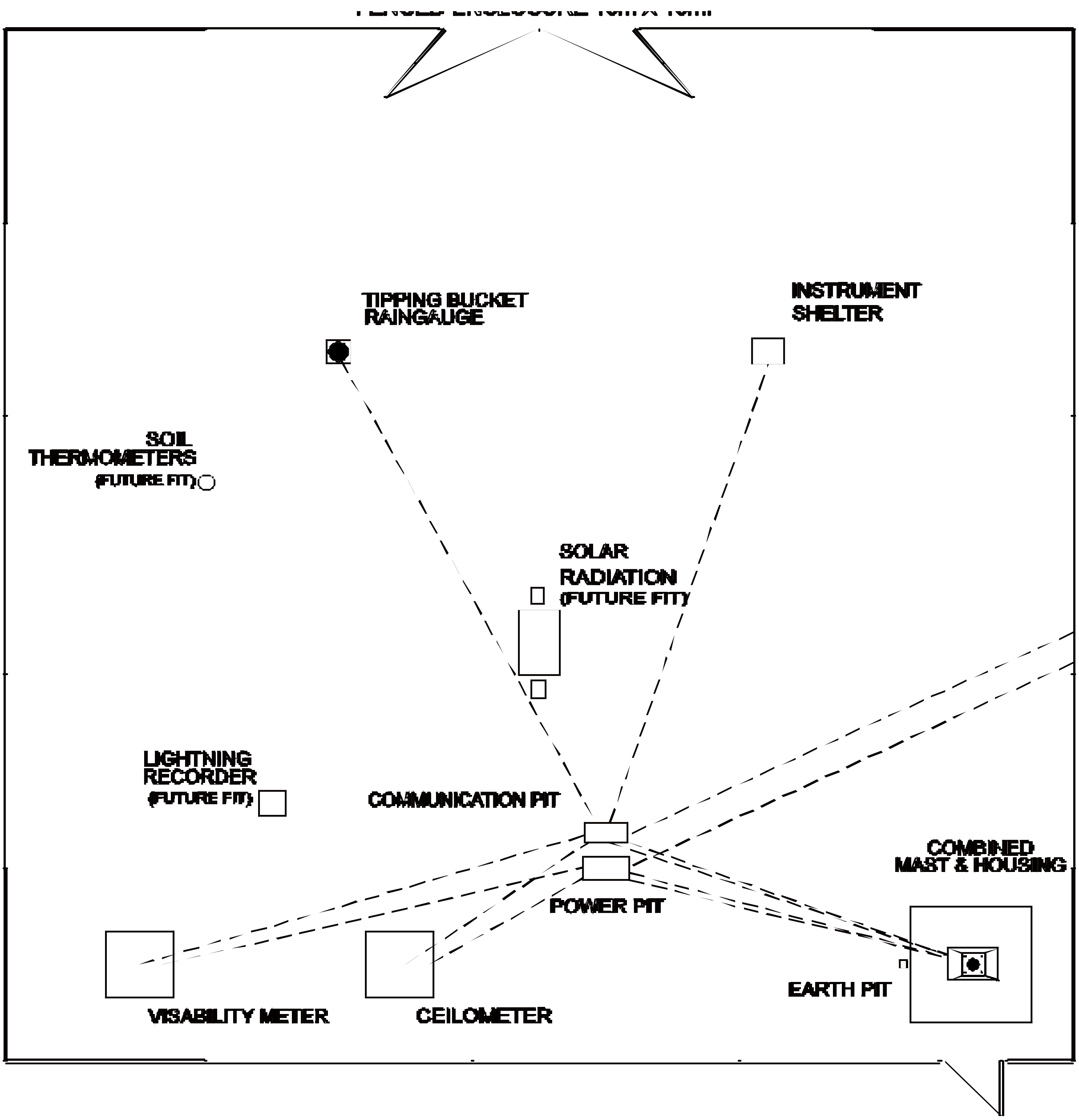
[Extract from: WMO-No 807, Commission for Instruments and Methods of Observation - Abridged Final Report of the Eleventh Session; *Geneva 21 February - 4 March 1994*.]

ATTACHMENT 2.

Attachment 3.

Meteorological Automatic Weather Station Equipment Layout.

Diagram 1. - Combined Mast and Housing. (Drawings still in approval stage at January 1997.)



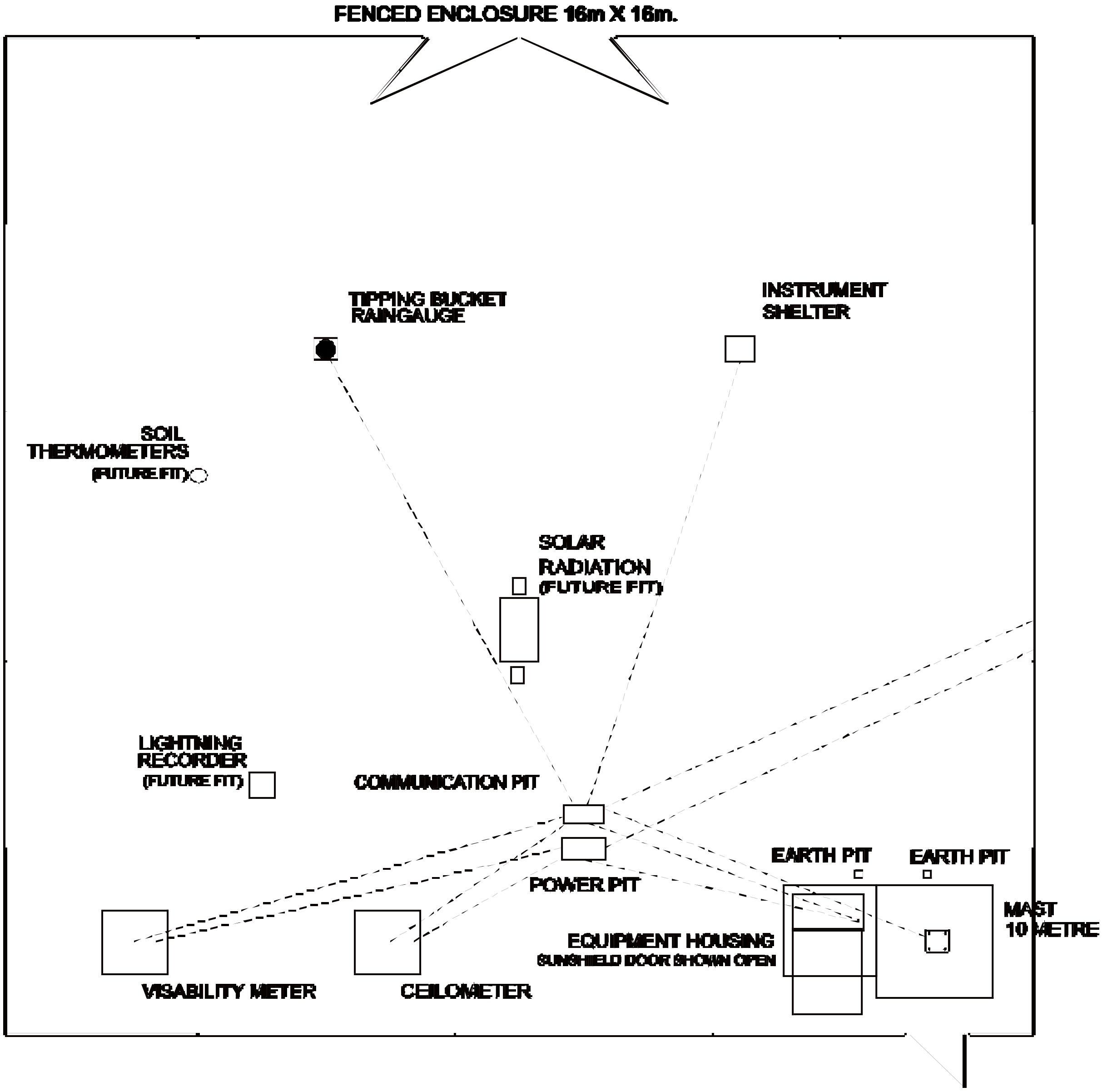
(For full details refer "AUTOMATIC WEATHER STATION, Combined Mast and Housing" Drawing No MA-22-01 sht 1.)

Note: 30m clearance zone radius centered at the mast.

Attachment 3.

Meteorological Automatic Weather Station Equipment Layout.

Diagram 2. - Stand-Alone Mast and Housing.

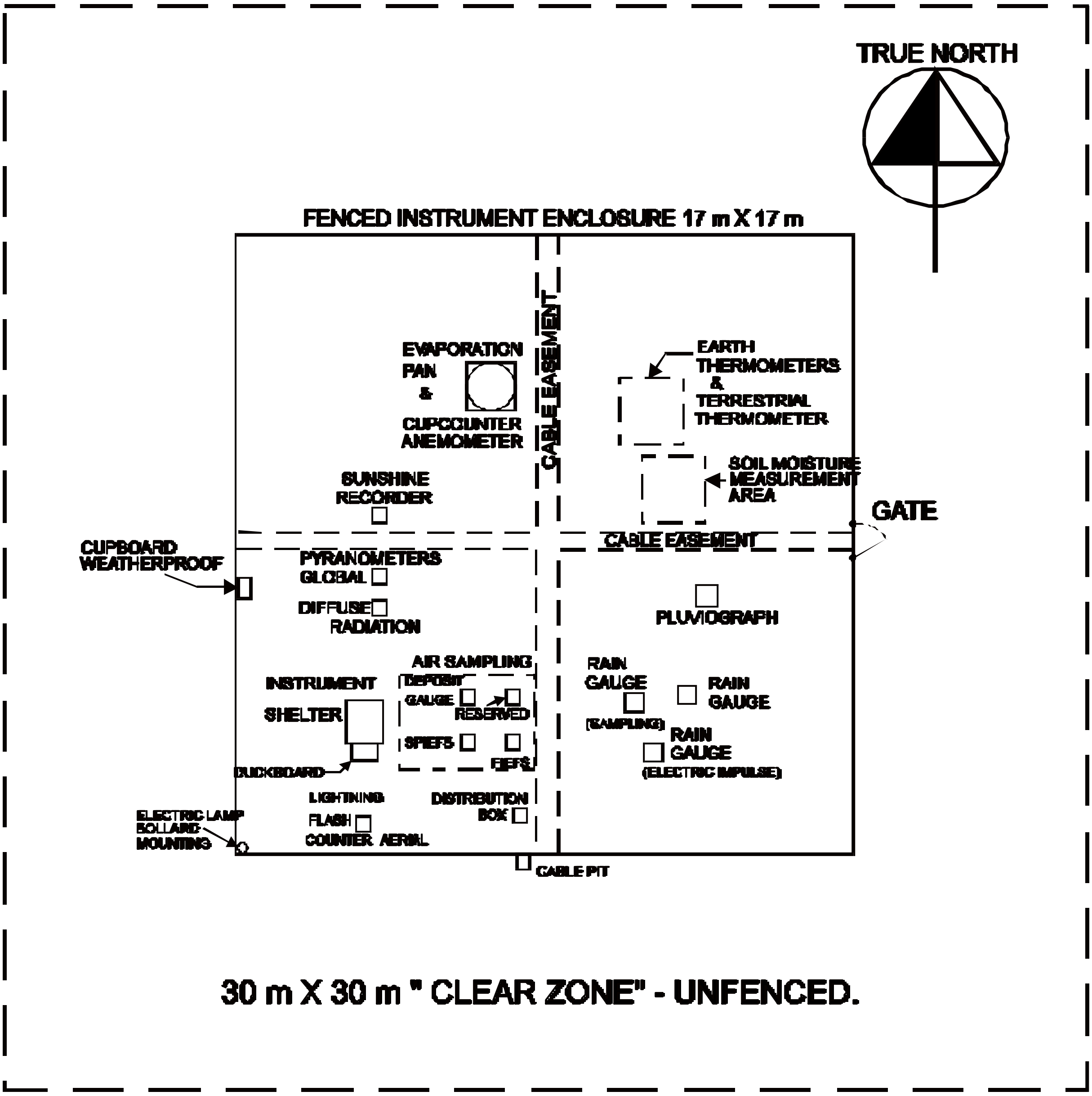


. . . . *(For full details refer "AUTOMATIC WEATHER STATION, Stand-Alone Mast and Housing" Drawing No MA-25-01 sht 1.)*

Note: 30m clearance zone radius centered at the mast.

Attachment 4.

<u>Meteorological Instrument Enclosure Equipment Layout.</u>



(For full details refer "INSTRUMENT ENCLOSURE METEOROLOGICAL EQUIPMENT LAYOUT" Drawing No SI-01-01. At January 1997)

<u>Notes:</u>

1. Enclosure to be surrounded by 1 metre high fence unless otherwise specified in site brief.
2. One 900mm wide gate to be located at the mid point of the enclosure side providing optimum access for observing staff. The path shall terminate at the gate and must not be laid inside the enclosure.
3. All instruments to be supplied by Bureau of Meterology.
4. Instrument shelter to be orientated with door facinf True South.
5. Enclosure must be orientated true North/South.
6. Unless otherwise specified in site brief, a hose cock and stowing hook are to be located against fence and near gate.
7. This drawing to be read inconjuction with Installation Specification No1145, Drawing Nos.II-01-01, EI-01-01 and site brief.

ATTACHMENT 4.

Bibliography.

Bureau of Meteorology Reference Climate Station Network Project. File 30/1465

Bureau of Meteorology *Surface Observations Handbook* Vol 1, 2 3. (New Version), and Vol A, B and C. (old version).

Chu, D.D. *A study of Atmospheric Flow in the Wake of a large Structure* (Dissertation submitted to Texas A & M University, December 1981.)

Civil Aviation Authority *Presentation of Meteorological Data* MFS-46 Draft Apr. 1991

Collinge, V., Kirby, C. *Weather Radar and Flood Forecasting* John Wiley & Sons 1987

Clift, G.A. *Use of Radar in Meteorology* W.M.O. Tech. Note 181 Ch. 8. 1985

Doviak, R.J., Zrnic, D.S. *Doppler Radar and Weather Observations* Academic Press 1984

Hanson, C.L. and Raizi, F. *Class A Pan Evaporation as Affected by Shelter, and a Daily Prediction Equation*. Agricultural Meteorology18 1977

I.C.A.O. Aerodromes - International Standards and Recommended Practices Annex 14 7th Ed. 1976

I.C.A.O. Manual of Aeronautical Meteorological Practice Doc 8896AN/893/3 Appendix C. 1986

I.C.A.O. *Meteorological Service for International Air Navigation* Annex 3 Rev. 1989

Melaragno, M. *Wind in Architectural and Environmental Design* Van Nostrand Reinhold Company 1982

Raithby, G.D., Stubley, G.D. and Taylor, P.A. *The Askervein Hill Project: A Finite Control Volume Prediction of Three Dimensional Flows over the Hill. Boundary Layer Meteorology* Vol 39 No 3 May 19 8 7 .

Shepherd, D. and Bally, J *Wind Speeds at Ile Des Phoques an Island off Tasmanials East Coast* Meteorological Note 190 Bureau of Meteorology February 1990.

Standards Association of Australia *Ambient Air - Guide for Measurement of Horizontal Wind for Air Quality Applications* A.S. 2923 - 1987

Standards Association of Australia SAA Loading Code Part 2 - *Wind Forces* A.S. 1170, Part 2-1983

Stull, R.B. *An Introduction to Boundary Layer Meteorology* Kulwer Academic Publishers Netherlands 1988.

Taylor, P.A. and Teunissen, H.W. *The Askervein hill project: Overview and Background Data Boundary Layer Meteorology* Vol 39 No. 1/2 April 1987.

U.K. Meteorological Office *Handbook of Meteorological Instruments*, Second edition, Volume 4, Measurement of Surface Wind, 1981

United States Federal Aviation Administration Order 6560.21 *Siting Guidelines for Low Level Windshear Alert System (LLWAS) Remote Facilities*.

Walmsley, J.L., Taylor, P.A. and Keith, T. *A Simple Model of Neutrally Stratified Boundary Layer Flow over Complex Terrain with Surface Roughness Modulations (MS3DJH/3r) Boundary Layer* Meteorology Vol 36 1986

World Meteorological Organization *Casebook on Hydrological Network Design Practice* WMO No. 324 1972 (incl. 1978 Sup.)

World Meteorological Organization *Guidelines on the Selection of Reference Climatological Stations (RCSS) from the Existing Climatological Station Network. World Climate Data Programme (WCDP)* July 1986

World Meteorological Organization *Guide on Meteorological Observations and Information Distribution Systems at Aerodromes* WMO No. 731 1990

World Meteorological Organization *Guide on the Global Observing System* WMO No. 488

World Meteorological Organization *Guide to Hydrological Practices* WMO NO. 168 TP 82 2nd Ed. 1970

World Meteorological Organization *Guide to Meteorological Instruments and Methods of Observation* WMO No. 8 5th Ed. 1983

World Meteorological Organization *Guide to Practices for Meteorological Offices Serving Aviation* WMO NO. 732 1990

World Meteorological Organization *International Operations Handbook for Measurement of Background Atmospheric Pollution* WMO No. 491

World Meteorological Organization *International Workshop on Precipitation Measurements.* Report No. 48 WMO No-328 1989

World Meteorological Organization *Technical Regulations Vol. 1 General Meteorological Standards and Recommended Practices* 1988

World Meteorological Organization, Commissions for *Instruments and Methods of Observation* - Abridged Final Report of the Eleventh Session; Geneva 21 February - 4 March 1994, WMO-No 807.

Instrument Instruction 54/24 of 8th November 1954.

'Cloud Searchlight Errors for Varying Baselines and Cloud Heights, for Both Inclined and Vertical Fixed Beams', H.O. File 45/6, 19th February 1975.