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Title The Planning of Frequency Allocations for VHF FM Broadcasting in Australia.

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Title The Planning of Frequency Allocations for VHF FM Broadcasting in Australia.

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INDEX - REPORT NO. 43

PART I - PROPOSED FREQUENCY ALLOCATIONS IN PHASE I OF VHF-FM SOUND BROADCASTING DEVELOPMENT IN AUSTRALIA - SUMMARY OF PREMISES AND CONCLUSIONS

		Page
1.	Premises on which frequency allocation proposals are based.	3
2.	Frequency band for FM services.	3
3.	System Standards.	4
4.	Nature of the services to be established.	5
5.	Required field strength and spacing of FM stations - notional receiver.	6
6.	Limitations in number of available FM channels by receiver interactions.	7
7.	Metropolitan/country weighting.	8
8.	Site selection for wide- and medium-coverage FM stations.	8
9.	Weighted lattice channelling plans for wide- and medium-coverage FM stations.	9
10.	Number of available channels in Stage 1 of FM development.	10
11.	Low-coverage stations - community stations.	11

PART II - FREQUENCY ALLOCATION PLANNING - DETAILED ENGINEERING BASIS AND PROCEDURE

1.	Inherent delays in provision of additional FM channels.	13
2.	System Standards.	13
3.	Minimum field strength required by (notional) FM receivers - Table I.	14
4.	Definitions of wide-, medium- and low-coverage - Table II.	15
5.	Typical powers and effective heights of wide-, medium- and low-coverage FM stations.	15
6.	Required distance and frequency separation of FM stations - Table III.	15

7. Interaction between FM and TV services - Tables IV and V. 17

8. Channel Allocation Rules (use for planning of low-coverage stations). 20

9. Site Selection. 21

10. Stage 1 Development - division of available band into segments - Table VI. 22

PART III - DETAILED FREQUENCY ALLOCATIONS FOR STAGE I OF FM DEVELOPMENT - EXISTING AND PROPOSED

1. Capital Cities - wide- and medium-coverage channels. 24

2. Other Areas - Proposed wide-coverage channels. 27

3. Other Areas (Provincial Cities and Towns) - Existing and proposed medium-coverage channels. 28

Appendix - Interference from FM station 3MBS to television services. 34

Fig. 1. Protection ratios required by VHF broadcasting services (after C.C.I.R.). 38

Fig. 2. TV receiver IF protection ratio required to avoid F.M. interference to TV service (after C.C.I.R.). 39

Fig. 3. Part of lattice frequency plan for wide-coverage FM stations - Stage 1. 40

Fig. 4. Part of lattice frequency plan for medium-coverage FM stations - Stage 1. 41

PART I

PROPOSED FREQUENCY ALLOCATIONS IN PHASE I OF VHF-FM SOUND BROADCASTING IN AUSTRALIA - SUMMARY OF PREMISES AND CONCLUSIONS

1. Premises on which the Frequency Allocations are Based

This Engineering Report No. 43 derives a plan of allocations for FM sound broadcasting channels proposed for use in the first phase of VHF-FM development in Australia.

This plan is built up by logical steps from a series of premises. Some of the premises are technical and economic, based on known engineering facts and in particular on successful operating experience elsewhere. Others are non-technical - they are sociological, political or philosophical. Many of the latter were presented to the Board's Engineering Division as formal directives, following on study papers from that Division or elsewhere: others exist as more or less formal inputs from other areas of present or previous government; some are assumptions considered "reasonable bases for initial planning" made by the authors of the report.

It is the purpose of this first section of the Report to identify as many as possible of these premises, particularly those in the latter categories given above, in order to bring to notice the consequences for the FM broadcasting service of a series of decisions taken over a considerable period of time and thus to permit an informed review of these decisions.

2. Frequency Band for FM Services

The choice of the band of frequencies within which frequency allocations can be made for FM broadcasting services in Australia is obviously the foundation for all individual frequency allocation proposals. This choice has been made by a series of decisions both overseas and in Australia extending over a considerable period of years and leading in April 1974 to government acceptance in principle of the recommendations of the Independent Inquiry into FM Broadcasting led by Sir Francis McLean.

The McLean inquiry recommended:-

(1) The establishment of FM broadcasting in the 88-108 MHz portion of the VHF band, using the pilot-tone stereo system.

(2) The transfer of the relatively few TV stations on Channel 5 to other VHF channels which had remained available for further limited VHF TV development.

(3) The establishment of the first phase of FM development in the portions 92-94 MHz and 101-108 MHz of the 88-108 MHz band.

(4) Transfer of 21 high-power TV stations from channels 4 and 3, possibly to new VHF channels to be made available by the displacement of non-broadcasting services, to permit the establishment of the second and third phases respectively of FM development.

In 1974 the Postmaster-General issued experimental licences for the first two FM stations (2MBS, 3MBS), in the 92-94 MHz band. The technical conditions of operation of these stations were determined by the A.B.C.B., including selection of those frequencies within the 92-94 MHz band expected to cause least interference to TV and non-broadcasting services. In 1975 the 92-94 MHz band was formally transferred by P.M.G.'s Department to the control of the A.B.C.B.

The Board has since called on its Engineering Division to prepare a timetable for clearing all TV stations from Channel 5. This clearance is now taking place in some areas, but in others only the most restricted development in the 92-94 MHz band is possible at present.

In the second stage of FM development, some 8 years later, the Channel 4 (94-101 MHz) TV stations are to move to a presently non-broadcasting part of the VHF spectrum, which will need to be cleared. In the third stage (20 years?) the TV Channel 3 (85-92 MHz) stations are to be moved into the 70-88 MHz part of the spectrum by a similar displacement of other services, to give the final clear FM band 88-108 MHz.

To reduce delays and expense in initiating FM services in Western Australia, the Board determined to establish Phase 1 of FM development in that State by clearing Channel 4 (occupied by National TV station Mawson) rather than Channel 5 (occupied by National TV station Bunbury, which shares a common aerial and mast with commercial station BTW on Channel 3).

The frequency bands available for Phase 1 of FM development are therefore as follows:-

Eastern states	92-94 MHz and 101-108 MHz,
Western Australia	92-94 MHz and 94-101 MHz.

Thus planning for the first stage of FM development has to provide a number of channels for all likely types of FM service, to the extent practicable within 9 MHz of spectrum.

3. System Standards

Given the total spectrum width available, the number of programme channels available depends on the spectrum required for each channel, which is determined by the transmission system adopted.

In 1974, following the acceptance of the McLean Inquiry Report, the A.B.C.B. determined and published "Standards for the Australian FM service" in terms of the pilot-tone compatible stereophonic system as specified in C.C.I.R. documents, in so far as the international agreements there recorded cover the specification for the transmitted signal. As part of the Standards, the Board decided to adopt the North American practice of dividing the 88-108 MHz band into 100 channels

each 0.2 MHz wide. (A pilot-tone transmission occupies just over 0.2 MHz of spectrum space, while limitations of receiver selectivity prevent channel spacings of less than 0.4 MHz in any one area.)

The main characteristic of the transmitted signal which is left to be decided nationally is the polarisation of the radiation from the transmitting aerial. This can be horizontal - requiring receiving aerials with horizontal rods for best results - vertical, or combinations of these two.

There are conflicting reports from overseas on this matter, and much evidence to support use of either horizontal or vertical polarisation: it is generally agreed that a combination of the two gives results equal to or better than either separately, but involves additional costs at both transmitting and receiving ends. The Board has decided to leave the final choice of polarisation until more experience had been gained, but determined on a provisional basis that the polarisation of FM transmissions should be the same as that of the main TV transmissions serving the same area: mixed polarisation could be approved in special cases where the advantages justify its use.

4. Nature of the services to be established

These have been planned to meet the requirements of the community, as evidenced in the response to the new opportunities FM offers for sound radio services.

These have been established:-

(a) In proposals for establishing FM services, submitted by a wide range of bodies over a period of years.

(b) By evidence at the Board's 1971 enquiry.

(c) In the proceedings of the Senate Committee on Broadcasting.

(d) In the proceedings of the McLean Inquiry, and discussions with Commissioners of the Inquiry.

(e) By submissions subsequent to the McLean report from community organisations and bodies studying the introduction of public broadcasting services; in particular these have stressed the need for local services covering very small areas such as a single suburb.

As a result of all these, the Board's planning has proceeded on the basis of four categories of FM station, defined as follows:-

Wide-coverage stations - with regional coverage comparable with that of many ABC medium frequency regional sound broadcasting stations or high power TV stations.

Medium-coverage stations	- with coverage of a metropolitan or similar area - comparable with that of existing commercial medium frequency stations.
Low-coverage stations	- originally intended to cover about 16 km. radius.
Very-low coverage stations	- intended to cover areas which may be as small as 2 km. in radius.

5. Required field strength and spacing of FM stations - Notional FM Receiver

In order to determine the field strengths needed for FM services, a specification is required of a notional FM receiver, or receiving installation, and in particular the field strengths it would require in order to provide, on a satisfactory statistical basis, the required grades of service in urban, suburban or rural receiving situations. In Australia, which unlike most overseas countries is starting a service with stereo included, rather than as a later "add-on", there are virtually two services to be considered in planning - a mono service with portable receivers, and a stereo service with fixed installations using outside aerials where necessary.

Although investigations by Board officers are proceeding on the relation between field strength and the grade of service desired from receivers available on the Australian market, the Board has agreed that until adequate local experience has been built up, the C.C.I.R. Recommendations for the required minimum field strengths for FM service under urban or rural conditions should be adopted as a basis for planning (Table I, Part II.3). This implies the assumption that the sensitivity of FM receivers available on the Australian market will be up to world standard.

Field strengths above the "urban" limit should give satisfactory mono reception with built in aerials, with some aerial improvement required for stereo reception.
Lower field strengths above the "rural" limit should give satisfactory stereo reception with good outside aerials, and mono reception with more modest aerials.

Table I, Part II.4, defines wide-, medium- and low- station coverage on the basis of C.C.I.R. field strengths.

Propagation information is required to determine the effective radiated power and height of transmitting stations to provide the field strengths specified in Part II.3 over the coverage areas defined in Part II.4.

It is available in general terms, summarised in C.C.I.R. documents, derived from North American and European experience with VHF-FM transmissions, and in specific local terms from our information on VHF television propagation in each area.

Further, it is proposed that the values for mutual interference to be expected between FM stations on the same or neighbouring channels, defined in current C.C.I.R. documents, should be adopted as a basis for planning at the present stage.

Following North American practice these values have been used to calculate the necessary geographical spacings between stations of wide, medium and low coverage (Table III, Part II.6).

This implies the assumption that the selectivity of FM receivers on the Australian market will be comparable with world standards: some of the receivers measured by the Board laboratory and 2MBS fall short of this.

As indicated in Section 3, receiver selectivity permits the reception of FM transmissions separated 0.4 MHz but this applies only where wanted and interfering signal strengths are comparable, such as would be experienced if both stations were of the same power and located at one site.

This is feasible, and is the basis for planning Stage 1 wide-coverage services, and may be feasible for some medium-coverage services, but is obviously impracticable for lower coverage stations which must be sited in the local area served.

Once random siting is accepted as necessary (as in U.S. or Canadian FM planning) it then follows that even a low-powered transmitter will be surrounded by an area - even though small - in which its signals are much stronger than those of other FM stations; to permit the latter to be received in such areas a wider spacing than 0.4 MHz is necessary; in the Americas the minimum spacing for stations in one area is 0.8 MHz, and this has been used in planning Stage 1 FM frequency allocations, until sufficient local experience has been acquired.

(There are recent moves in North America and in Europe, with tightly supervised receiver specifications, to reduce this spacing.)

The coverage from a network of FM stations is not in principle increased by the use of directional transmitting aerials. Their use does however permit the location of individual transmitting sites offset from the centre of the area to be served, and therefore makes it easier to exploit any elevated structures or sites available. The area of interference produced for a given coverage is much the same, but displaced. A directional aerial may therefore sometimes be useful to direct this interference into a less inhabited area, e.g. out to sea in coastal areas, and thus improve overall coverage.

6. <u>Limitation by receiver interactions, in number of available FM channels</u>

In the first phase of FM development there are nominally forty-five 0.2 MHz FM channels in the 9 MHz of spectrum available. The number of stations which can be allotted channels in any given area is limited by the interaction of each FM transmission with:-

(1) Other FM services on the same channel.

(2) Other FM services on neighbouring channels (this has been discussed in (5) above).

(3) TV services on neighbouring or related frequencies.

(4) Radio-communication services on neighbouring or related frequencies.

The severity of these interactions depends primarily on imperfections in the performance of the FM, TV or radio-communication receivers involved. Cost restrictions on the performance of domestic receivers in many cases severely limit the efficiency of utilisation of the spectrum - for example it is considered by the authors of this Report that, apart from any questions of FM receiver selectivity restricting the closeness of spacing of FM stations, the limited selectivity of existing TV receivers in Sydney and Melbourne and interactions with non-broadcasting services, could reduce the number of possible channels for wide- and medium-coverage FM services in those areas in Phase 1 of FM development, from 45 to about 22.

7. Metropolitan/Country weighting

A decision must be made, as regards the wide- and medium-coverage services, on the relative weight to be given to metropolitan broadcasting services in comparison to broadcasting services in other areas. The two extreme planning philosophies are:-

(a) "patch" coverage, in which as many channels as possible are allotted to each metropolitan area in isolation, and country allocations are fitted around these as feasible,

(b) "lattice" coverage, in which a uniform network of stations covers the whole of the populated area, providing the same number of channels at every location.

A decision such as the choice of this relative weighting is not one for planners to take, but for the community through its organisations; the view of the community of the use to be made of this new service is not yet clear; it seems unlikely however that either extreme would be adopted, and as a basis for planning in Stage 1 a "weighted lattice" providing twice as many wide- and medium-coverage services in metropolitan-centred areas as in other areas has been used; if this is wide of the demands as they become identified, it will be possible to readjust the balance in Stage 2 planning, if not earlier, without difficulty.

8. Site Selection for wide- and medium-coverage FM stations

The wide-coverage FM transmitters are intended primarily for 'blanket' coverage of programmes. To achieve this with the most economical use of available channels requires that equal power transmitters be spaced according to a regular lattice. Allowing for the irregularities in coverage introduced by terrain variations, the existing regional (national plus commercial) TV transmitter sites provide a reasonable approximation to the required spacing and arrangement of wide coverage FM

transmitters. Because of this, and the considerable economies of using established sites, it has been accepted by all bodies (and used as a basis for the McLean Report), that the wide-coverage FM transmitters will be established at these 40 sites, whatever their ownership or radiated programmes.

In many cases an existing tower can be used to support the FM transmitting aerial thereby permitting additional savings in the implementation of the service.

A direction was given by the previous government for the A.B.C.B. and Telecom Australia to commence technical planning for the eventual grouping of up to six wide-(and in some cases medium-) coverage services at each of the 40 main TV transmitting sites.

For medium-coverage services, in most cases, the transmitter will need to be located on high buildings or high land close to the centre of the service area. In general this choice permits best coverage of the desired service area with relatively simple aerials. Because of the resulting greater potential interference in surrounding areas and consequent restrictions on their FM frequency allocations, the dominant regional TV sites should not in general be used for medium-coverage services.

As a first step in the planning process, towns with a population of 5,000 or greater have been selected as the sites of medium-coverage transmitters. This choice gives a reasonable spread of transmitters and, in the more closely settled areas of southern/eastern Australia generally makes the areas contiguous or overlapping.

However, in South Australia and Western Australia, towns of 2,000 or more people have been selected so that a reasonable distribution of transmitters results.

9. Weighted lattice frequency plans for wide and medium coverage stations

"Weighted" lattice plans as outlined have been drawn up for a set of wide-coverage stations located at the existing 40 high-power TV transmitter sites, and for a set of medium-coverage stations located at, or providing urban coverage to, the 120 centres in Australia having 5,000 population or greater (2,000 in S.A., W.A.).

It is found that a set of 10 contiguous channels (occupying 2.0 MHz) is necessary to provide a wide-coverage "weighted lattice", providing two programmes to metropolitan 'TV regions'; and one to all other 'TV regions'.

Coincidentally, a set of 10 contiguous channels (occupying 2.0 MHz) is again found necessary to provide a medium-coverage 'weighted lattice' providing two programmes to each metropolitan area, and one to all other centres of 5,000 population or above (2,000 in S.A., W.A.).

It is found that the most efficient use of channels is obtained by grouping stations of the same type, but geographically separated, into a block of channels, so that every channel can be used at as close a spacing as possible. This leads to a

division of the available 9 MHz band as follows:-

92-94 MHz.	Used for some existing wide- and medium-coverage stations and to provide channels for many of the experimental educational FM stations - may be used for additional medium coverage stations if special conditions are applied to site, aerial patterns.
101-102 MHz.	Not usable in areas with Ch. 2 TV because of TV receiver oscillator radiation; used for additional medium-coverage stations in Newcastle and Wollongong - also for existing wide-coverage Ch. 1 ABC-FM in Canberra.
102-104.4 MHz.	Medium-coverage stations according to 'weighted lattice' plan.
104.4-106.4 MHz.	Wide-coverage stations, co-sited with TV transmitters.
106.4-108 MHz.	Intended for low-coverage stations, but may be used for additional medium-coverage stations in capital cities.

An analogous scheme is proposed for Western Australia.

10. Numbers of Available Channels for Stage 1 of FM development

Based on these concepts, a detailed channel allocation plan for nearly 220 wide- and medium-coverage FM stations for Phase 1 of FM development, is given in Part III of this report. The plan naturally includes the frequency determinations already made by the Board for the four initial ABC FM stations now in operation, and for the nine educational FM stations now licensed.

In the main cities, this provides the following numbers of channels:-

	Wide	Medium Coverage
Sydney	3	5
Melbourne	2	6
Canberra	3	4
Brisbane	2	5
Adelaide	3	5
Perth	2	4
Hobart	2	4
Newcastle	1	4
Wollongong	1	2
Launceston	1	2

It will be noted that the numbers of channels are appreciably lower than those given in the McLean Report. This is because it is considered the latter:-

(1) Does not make sufficient allowance for interference to TV services of the forms predicted by the A.B.C.B. in Report No. 34. The reality of such interference has since been established by the experience gained from the interference caused to television viewers by experimental station 3MBS (see Appendix), by ABC wide-coverage station 3-ABC/FM in Melbourne and by stations 2MBS and 2-ABC/FM in Sydney.

(2) Assumes that FM stations may be operated wherever feasible in Channels 3 and 4 during phase 1 of FM development.

(3) Is based on the concept of "patch" coverage of the Newcastle-Sydney-Wollongong conurbation. The current planning assumes that listeners in adjacent areas should have as many FM channels as Newcastle or Wollongong, and half as many as Sydney.

The 19 wide-coverage or 36 medium-coverage stations estimated as feasible for Newcastle-Sydney-Wollongong in Phase 1 in the McLean report are thereby reduced to 5 wide-coverage plus 13 medium coverage stations. If more channels are required in capital cities in Phase 1 they can be provided:-

(1) By transferring channel allocations from centres within 200 km.

(2) By using Channels 3 and 4 (e.g. medium-coverage stations in Channel 4 in Newcastle).

(3) By accepting increased interference to FM and/or TV services by departing from the channel allocation rules set out in Part II.8 of this report.

(4) By placing FM station channels closer together than 0.8 MHz in the same area, at the expense of denying FM reception to some listeners with receivers of poorer selectivity.

It is self-evident that if further spectrum space has not been cleared for FM by the time the channel allocations listed in this Report have been exhausted, some or all of the above measures will have to be employed, and there is a danger of the FM band becoming as congested as the existing AM broadcasting band.

11. Low-Coverage Stations - Community Stations

If the opportunities offered by this new broadcasting service to establish relatively large numbers of low-coverage services are taken up by the community, then the centralised planning of large numbers of small stations ahead of the individual demands for them becomes both prohibitively complex and needlessly restrictive of initiative. The North American practice may therefore be appropriate which requires applicants to submit their

own proposals for frequencies and technical conditions (of low or very low-coverage stations, in our case) in accordance with a defined set of rules to permit them to co-exist with an established lattice plan (for our wide- and medium-coverage stations). This is under consideration.

The number of low-coverage stations which can be provided in Stage 1 in, say, the Sydney metropolitan area depends on their power and location - hence the limitations of centralised planning indicated above.

However, consideration of Table III, Part II.6 makes it clear that even very low coverage stations using a common channel must be separated by 20-30 km.

The eight local-coverage stations for which the Sydney Broadcasting Study Group has reported a community demand are sufficiently spaced so that 7 or 8 contiguous channels could accomodate them.

The Study Group also sees a demand for initially 3, later 4 more community stations of metropolitan coverage. If there is a demand of similar magnitude from commercial broadcasters they cannot all be accomodated in Phase 1 of FM development as defined.

PART II

FREQUENCY ALLOCATION PLANNING -

DETAILED ENGINEERING BASIS AND PROCEDURES

1. Inherent delays in provision of additional FM channels

Detailed proposals for the provision of VHF bands for FM sound broadcasting are included in the McLean report. It is to be stressed that if more spectrum space than the almost immediately available 9 MHz is to be provided to FM in 10 years time as proposed in the McLean Report, then the decision to clear the additional channels must be made shortly, with immediate funding and action, because of the long lead times involved in the transfer of the DME system. If this is not done then congestion in the FM band is likely, some time in the 1980's, to reach the levels already being experienced overseas, with the consequent need to open up a third sound broadcasting band in the UHF or SHF region.

2. System Standards

These have been determined and published by the Board as a separate document. Frequency allocations are affected in particular by the following:-

(a) Polarisation

The specification of the polarisation of transmitted signals to be the same as that of local TV services leads to some advantages in the reduction of co-channel signals from FM stations in other areas, as it follows the polarisation alterations of the TV plan. The permitted alternative of mixed horizontally and vertically polarised radiation leads to a similar result, if reasonably accurate circular polarisation of a standardised phase rotation is radiated, and the minority of listeners subject to co-channel interference use circularly polarised receiving aerials.

(b) Bandwidth of Radiated Signals: Nominal Channel Width

The radiated spectrum of an FM transmission theoretically comprises an infinite number of sidebands; it is usual to consider them significant down to the level of 1% of unmodulated carrier amplitude; elimination of sidebands of larger amplitude than this either in transmission or reception leads to perceptible distortion at high modulation levels. With sufficient accuracy for frequency allocation purposes, the radiated bandwidth of a monophonic FM sound transmission is given by Carson's Rule as:-

$$2 \times (\text{deviation} + \text{highest modulating frequency})$$

giving a bandwidth of 2 (75 + 15) = 180 kHz for the Australian FM system.

The situation with a pilot-tone transmission is more complex, and a bandwidth of 200-220 kHz if often quoted.

Following the example of the United States and Canada, Australian FM Channels have been designated at 200 kHz intervals from 88-108 MHz (Channel 201 centred on 88.1 MHz, Channel 300 centred on 107.9 MHz). It is not practicable to allot adjacent channels in the same area because of limitations of receiver selectivity.

3. Minimum field strength required by (notional) FM receivers

There have been specified in C.C.I.R. 1974 (Vol X Recommendation 412.1) in millivolts/metre at a height of 10 metres, as follows:

Table I

	Mono	Stereo
Minimum field strength, in absence of interference from industrial and domestic equipment.	0.05mV/m	0.25 mV/m using a multi-element aerial.
Median field strength, in presence of interference:		
- Rural areas	0.25mV/m	0.5mV/m
- Urban areas	1.0	2.0
- Large cities	3.0	5.0

It is considered from observation of overseas FM reception practice that satisfactory results are obtained for mono reception with built-in or 'random' aerials (extensible whips, etc), down to a median field strength as defined above of 1.0 mV/m, with improved aerials in some cases for stereo reception. Below a median of 0.25 mV/m mono reception requires multi-element units, and satisfactory stereo reception is not available even with these.

For the Australian service, which unlike most of those overseas is being planned from the beginning as a dual mono/stereo service, the limits of coverage have therefore been taken as:

Urban coverage - median field strength of 1.0 mV/m at 10 metres height

Rural coverage - median field strength of 0.25 mV/m at 10 metres height

although there may be some mono listeners beyond these limits.

4. The coverage radii to the median field-strength boundaries defined in (3) above, have been taken at the following values to give effect to the definitions of wide-, medium- and low-coverage stations given in the introduction (the exact values have been chosen to give rounded values for transmitter powers and heights).

Table II

Wide-coverage	Rural	112 km
	Urban	80 km
Medium-coverage	Rural	56 km
	Urban	32 km
Low-coverage	Rural	29 km
	Urban	15 km

It is emphasised that these are planning categories and not 'strait-jackets' to which all stations must conform; intermediate values will continue to be useful to 'tailor' the coverage to the community to be served. Directional aerials may be used if necessary to locate FM stations "off-centre" in their coverage area, or to minimise interference in particular directions.

5. The three categories of station - wide-, medium- and low-coverage may be quantified in terms of the effective height above terrain of their transmitting aerials, and the effective radiated power required to give the field-strengths defined in (3) above over their coverage area of radius given in (4) with the aid of the propagation information referred to in the introduction.

Note:- (i) The received field strength within a few wavelengths of the ground is proportional to the product,

$(\sqrt[2]{\text{effective power}}).(\text{effective height above terrain})$

Thus, doubling the terrain height is equivalent to increasing power four times - it is therefore meaningless in terms of coverage to rate stations in terms of power only.

Typical power/height combinations would then be:-

Wide-coverage - 50 kW erp, effective height above terrain 500 metres (1600'),

Medium-coverage - 10 kW erp, effective height 90 metres (300'),

Low-coverage - 1 kW erp, effective height 60 metres (190').

(ii) For wide- and medium-coverage, the effective height is defined as the height of the aerial centre above the average ground level between 3km and 16km in the direction concerned. It can thus vary in different directions.

6. (a) The distance between co-channel stations must be much greater for pilot-tone stereo than for monophonic FM; because of the presence of an AM sub-carrier the "capture effect" is largely absent. Unlike the case of TV stations, offsets are of little value; in fact the worst mutual interference occurs not for the exact co-channel situation, but in the case where carriers are separated by the sub-carrier frequency, 38 kHz.

C.C.I.R. Recommendation 412.1 (see Fig. 1 at end of Report), gives the required protection ratios for FM transmissions using the same or neighbouring frequencies, as a function of the frequency separation. For wide-coverage stations, co-channel interference will be subject to fading, and a higher maximum interference level is tolerable than for steady interference between nearer lower coverage stations. Tests carried out by the Board, and the Music Broadcasting Society of NSW have shown that a substantial proportion of FM receivers on the Australian market require more protection than the C.C.I.R. report suggests.

(b) The McLean report recommended that separation between FM stations in the same area should be 800 kHz, but considered closer spacing could be used later with improvements in receivers.

The North American FM planning, where stations are scattered on random sites, also uses a minimum of 800 kHz, and it seems desirable to keep to this figure until some experience is gained. With random siting of FM transmitters, even though low in power, some neighbouring FM receivers will need to reject much stronger unwanted signals than those they seek to receive from other more distant transmitters; with co-sited stations the wanted and unwanted stations are comparable in signal strength throughout the whole service area, and closer frequency spacings are then more feasible. The North American planning converts the required signal strengths and protection ratios into permitted mileage separations between stations of their chosen categories using the same or neighbouring FM channels. The metric equivalent of these, extended to apply to the categories of stations called for by the McLean report and later community demands, are given in Table III below.

Table III

Category of Station	Typical Data: Height above terrain; e.r.p.		Coverage Radius (km) Urban Ø	Rural*	Minimum distance (km) between stns. of same category Co-Chán.	1 Chan. sprtn.	2 Chan. sprtn.	3 Chan. sprtn.
Wide-coverage	500m	50kW	80	112	300	225	145	110
Medium-coverage	90m	10kW	32	56	210	130	64	48

Category of Station	Typical Data: Height above terrain:	e.r.p.	Coverage Radius (km) Urban Ø	Rural*	Minimum distance (km) between stns. of same category Co-Chan.	1 Chan. sprtn.	2 Chan. sprtn.	3 Chan. sprtn.
Low-coverage	60m	1kW	15	29	130	72	32	24
Low-coverage Mono	60m	1kW	15	15+	95	46	20	14
Very Low-coverage Mono	30m	100W	7	7	57	17	9	-
Very Low-coverage Mono	30m	10W	3	3	30	8	9	-
" "	15m	10W	2	2	21	5	-	-

Stations separated by 4 channels (800 kHz) or more may be co-sited. Note that because of earth curvature, the coverage radius of wide-coverage stations is a considerably higher proportion of the maximum inter-station spacing than for smaller stations.

Ø Mono coverage with built-in or 'random' aerial. Stereo coverage with some attention to aerial system.

* With outside aerial if necessary.

\+ No additional rural coverage - interference limited.

Note:- No consideration has been taken in deriving the above distances, of the possible reduction of mutual interference obtained by the use of cross-polarisation. This reduction may be taken as 10dB for planning purposes for listeners with good outdoor aerials, but non-existent for 'random' aerials.

7. (a) At least for the initial 20 years of FM band broadcasting development, it is obvious that the 88-108 MHz band will be shared between FM and TV, and interference between the two services using the same frequencies in neighbouring areas must be taken into consideration. The severity of this form of interference does not depend so much on the absolute signal strength, but primarily on the ratio of the wanted to unwanted signal strength and the necessary 'protection ratio' to avoid interference.

C.C.I.R. documents specify these for notional FM and TV receivers. The required protection ratio specified by C.C.I.R. for TV receivers is given in Table IV below. Some Australian TV receivers have been found to require more protection than these documents specify. Colour receivers require more protection than monochrome receivers for interfering signals more than 3.5 MHz above vision

Table IV

Protection ratio required by System B/G TV receivers against a CW or frequency-modulated signal.

(From C.C.I.R. Recommendation 418-2 and Report 306-2)

Frequency of interfering signal (relative to TV vision carrier frequency)	Minimum required Ratio of TV signal to interfering signal	
	Monochrome Receiver	Colour Receiver
-3.0 MHz	+2dB	+2dB
-1.5	2	2
-1.0	27	27
+0.1	50	50
+1.0	50	50
+2.0	41	41
+3.0	32	32
+3.5	28	28
+3.9	25	45
+4.0	24	45
+4.5	20	45
+4.9	20	45
+5.0	25	35
+5.5 ± 20 kHz	43	43
+5.5 ± 50 kHz	30	30
+6.0 MHz	13	13

(b) Interference may also be due to non-linearity in the receiver, causing interference "beats" between FM and TV signals of harmonically related frequencies. In these cases, the absolute levelof the interfering signal at the input to the receiver is the important quantity, the strength of the wanted signal being less important. This has been discussed in detail in A.B.C.B. Report No. 34 and its addendum of January, 1974.

Some of the main conclusions are summarised in Table V below and Fig. 2 (end of Report).

Table V

Harmonic Interference from FM to TV

(from A.B.C.B. Report 34 - January, 1974 addendum)

Interference observable on at least one receiver of the chosen sample of six 1965 - 1972 Australian monochrome receivers - at wanted TV levels of 50-70dBu. Not applicable tc co-sited stations.

TV Channel Being Received	For high-power FM (interfering field 90dBu)	For low-power FM (interfering field 80dBu)
Ch. 0	91.2-99 MHz	91.5-95 MHz
Ch. 6	87 -89.5	87.5-89
Ch. 7	90.5-93	91 -92.5
Ch. 8	94 -96.5	94.5-96.0
Ch. 9	97.5-100	98 -99.5
Ch.10	104 -106.5	104.5-106

(c) The same non-linearities give rise to mutual interference when one of three services

- (IFM & 2TV) or (2FM & 1TV) -

has a frequency which is close to the sum or difference of strong signals from the other two:

e.g. $FM_{92.1} + FM_{90.1} = TV_{182.2}$ (Ch. 7 TV vision carrier),

or in cases where two strong signals are separated by the intermediate frequency of the receiver:

e.g. $FM_{101.3} + TV\text{-}IF_{36.9} = TV_{138.2}$ (Ch. 5A vision carrier).

(d) Local oscillator radiation from TV and FM receivers must also be taken into account. Thus TV receivers in most capital cities, tuned to Ch. 2 will have a nominal oscillator frequency of:

$TV_{64.2} + TV\text{-}IF_{36.9} = \text{Local oscillator}_{101.1}$

In practice the frequencies of radiation from such receivers will be distributed in a Gaussian or bell-shaped curve, about 101.1 MHz as a centre, with a spread of up to $\pm$ 1 MHz. Interference to FM receivers close to the TV receivers will therefore extend over much of the FM band 100-102 MHz.

Similarly the use of channel 1 in an area would give rise to interference to FM stations between 93 and 95 MHz.

It is because of FM receiver local oscillator radiation that the U.S. chose, and the world has standardised on an FM IF of 10.7 MHz, so that oscillator radiation falls half-way between channels at 200 kHz spacing (because of direct IF breakthrough it is still found necessary to avoid pairs of FM stations at 10.6 or 10.8 MHz separation).

The Australian FM service will initially develop in the 101-108 MHz band, with FM receiver local oscillator radiation falling in the 111-119 MHz aeronautical communication band. It is therefore necessary to avoid FM frequencies which would put local oscillators both physically close and co-incident in frequency with such services as, e.g. control towers at Mascot or Tullamarine.

The restrictions imposed on FM frequency allocations by the above considerations have been summarised in the following set of rules which should be useful, in particular in considering subsequent proposals for low power stations.

8. Channel Allocation Rules

In selecting the particular frequencies available for FM station use in each area, the following modes of interaction between FM and other services must be avoided:-

Interference by FM

(a) Co-channel interference to existing TV or other non-broadcast services. For TV serving the same or an overlapping area, the whole TV channel should be avoided. For adjacent, non-overlapping areas only the TV carrier frequencies f_{v_c} (vision carrier), f_{c_c} (colour sub-carrier), f_{s_c} (sound sub-carrier) need be avoided, except that in any case the protection ratios for TV defined in C.C.I.R. Report 306 must be met (see Table IV).

(b) The 2nd harmonic of the FM transmitter frequency falling on the frequency of an existing local service or in parts of a TV channel used locally. If the FM and TV transmitters are co-sited, only f_{v_c}, f_{c_c}, f_{s_c} need be avoided (see fig. 2 and Table V).

(c) The FM receiver local oscillator frequency coinciding with that of an existing local service.

(d) The 2nd harmonic of the FM receiver local oscillator coinciding with the frequency of an existing local service or f_{v_c}, f_{c_c}, f_{s_c} of a TV channel serving the same area.

(e) Second-order intermodulation products (sum and difference frequencies) of FM signals with other FM and existing TV and non-broadcast services falling on the frequencies of existing services. Products falling in a TV channel will have various effects depending on the frequency difference between the video carrier and the interfering signal. In some cases the interference may be negligible.

Interference to FM

(a) If TV channel 1 or 2 is used in the area, radiation from TV receiver local oscillators interfering with reception on certain FM channels. TV channel 1 receiver local oscillators operate over the range 92.5 to 94.9 MHz, and near 96.1 MHz, while TV channel 2 local oscillator cover 99.5 to 101.9 MHz, and near 103.1 MHz.

(b) FM frequency spaced by 10.7 MHz (FM receiver IF) from an existing local service. This avoids the generation, in the FM receiver front end, of a spurious signal at intermediate frequency.

(c) Image interference to FM reception by a local service (21.4 MHz above the FM frequency).

(d) Self-interference to FM if 96.3 MHz ± 100 kHz is used as it is the 9th harmonic of the FM receiver IF.

(e) Interference to FM reception arising from frequency doubling of a strong channel 0 TV signal in the FM receiver front end. To avoid this, FM channels at twice the frequency of TV

channel 0 carriers should not be used in areas served by TV channel 0.

9. Site Selection

The wide coverage FM transmitters are intended primarily for 'blanket' coverage of programmes. To achieve this with the most economical use of available channels requires that equal power transmitters be spaced according to a regular lattice. Allowing for the irregularities introduced by terrain variations, the existing regional National plus commercial TV (100 kW) transmitter sites provide a reasonable approximation to the necessary arrangement of transmitters. Therefore these sites (40 in all) will be used for the wide-coverage FM transmitters. In many cases an existing tower can be used to support the FM transmitter aerial thereby permitting considerable savings in the implementation of the FM service.

For medium-coverage services, in most cases, the transmitter will be located on high buildings or high land close to the centre of the service area. In general this choice permits best coverage of the desired service area with relatively simple aerials. Because of the resulting greater potential interference in surrounding areas, and consequent restrictions on their FM frequency allocations, the dominant regional TV sites will not in general be used for medium-coverage services.

However there are some cases where it may be more efficient to provide, for example, metropolitan coverage by a relatively narrow-angle horizontally directional aerial from the neighbouring dominant TV site, the radiation overshooting the service area being in a direction where it will not cause interference problems, e.g. out to sea in the case of Perth.

As a first step in the planning process, towns with a population of 5000 or greater were selected as the sites of medium power transmitters. This choice gives a reasonable spread of transmitters and in the more closely settled areas of southern/eastern Australia generally results in overlapping or adjacent service areas.

However in South Australia and the south/west of Western Australia, towns of 2000 or more people have been selected so that a reasonable distribution of transmitters results.

Co-incidentally the potential sites so obtained generally correspond to those areas that at present support a commercial MF station.

Low and very low coverage stations must be sited at the centre of their proposed service area to achieve the desired coverage, except where a highly directional aerial is located at the edge of the service area. However this approach may result in additional interference in some surrounding areas, and must be used with caution.

'Weighted' lattice plans as outlined in the introduction have been drawn up for a set of wide-coverage stations located at the existing 40 high-power TV transmitter sites, and for a set of medium-coverage stations located at or providing urban coverage to the 120 centres in Australia having 5,000 population or

greater (2000 in S.A., W.A.). Figures 3 and 4 (end of Report) show typical sections of these lattice plans.

It is found that a set of 10 contiguous channels (occupying 2.0 MHz) is necessary to provide a wide-coverage 'weighted lattice', providing two programmes to metropolitan 'TV regions' and one to all other 'TV regions'.

Co-incidentally, a set of 10 contiguous channels (occupying 2.0 MHz) is again found necessary to provide a medium-coverage 'weighted lattice' providing two programmes to each metropolitan area, and one to all other centres of 5,000 population or above (2,000 in S.A., W.A.).

A direction was given by the previous Government for the A.B.C.B. and Telecom Australia to commence technical planning for the eventual grouping of up to six wide (or in some cases medium) coverage services at each of the 40 main TV transmitting sites, even though their programme material may come from diverse sources. (There are considerable economies achievable by the combined use of a single transmitting aerial, and other joint facilities). A substantial proportion of the whole 20 MHz-wide FM band will be necessary to provide channels for these, but it is clearly desirable to establish the early stations in accordance with the long-term plan.

10. Stage I Development - Division of available band into segments

So that orderly development of the various classes of FM services can commence, the available band space is broken into segments according to the estimated requirement for stations in each category. Using the 'weighted lattice' approach the Stage 1 plans in this category provide for 2 wide- and 2 medium-coverage stations in capital cities.

For a number of reasons, the provision of wide-coverage services such as the ABC FM network is not likely to be very rapid, and the major development of FM in Stage 1 will be by means of various types of medium-coverage stations. Consequently, the medium coverage plan has been extended to increase the number of channels available in capital cities for these stations. This extension occurs mainly at the expense of channels for low-coverage stations in the relevant area. However some low-coverage stations can, if desired, share parts of TV channels 3 and 4 (not available for wide- and medium-coverage stations in Stage 1) without causing interference to existing channel 3 and 4 TV services. (In W.A. parts of channels 3 and 5 may be available if necessary for low-coverage stations in Stage 1).

The band segments and the associated major uses are detailed in Table VI.

Table VI

Outline of Channel Allocations vs Transmitter Category - Stage 1 of FM Development

Band Segment	Use
92.1 to 93.9	Used for some existing wide- and medium-coverage stations and to provide channels for many of the experimental educational FM stations; may be used for additional medium-coverage stations if special conditions are applied to site, aerial pattern.
101.1 to 101.9	Not usable in areas with channel 2TV; used for additional medium-coverage stations in Newcastle and Wollongong; also for existing 1 ABC-FM in Canberra.
102.1 to 104.3 (not W.A.) 95.1 to 97.3 (W.A. only)	Medium-coverage stations according to 'weighted lattice' plan.
104.5 to 106.3 (not W.A.) 97.5 to 99.3 (W.A. only)	Wide-coverage stations.
106.5 to 107.9	Intended for low-coverage stations only but used for additional medium-coverage stations in capital cities.

PART III

DETAILED FREQUENCY ALLOCATION FOR STAGE I OF FM DEVELOPMENT - EXISTING AND PROPOSED

As a consequence of the above planning criteria the following frequency allocations result for Stage 1 of FM development.

Existing - Frequencies already determined by A.B.C.B.

Proposed - Planned frequency only - subject to individual determination by A.B.C.B.

1. Capital Cities - Wide- and Medium-Coverage Channels

CANBERRA

Existing:	1ABC-FM	101.9 MHz	Ch.No. 270
Proposed:	Wide-Coverage Channels	104.7	284
		105.7	289
	Medium-Coverage Channels	102.7	274
		103.9	280
		*106.7	294
		*107.7	299

SYDNEY

Existing:	2MBS-FM	92.1	221
Existing:	2ABC-FM	92.9	225
Short-term proposal for ABC second-service (medium-coverage only)		93.7	229

This is proposed as a short-term expedient if the service is required to commence before TV Ch. 5 Newcastle has been transferred to Ch. 5A. It must be restricted to medium-coverage only because of the danger of interference to TV Ch. 4 reception in the area between Wollongong and Sydney.

Because of the potential for interference to TV service, in the longer term it would be desirable to transfer both ABC allocations to the 101-108 MHz band, leaving 92.9 and 93.7 MHz for extra medium-coverage services co-sited with TV.

Proposed:	Wide-coverage	104.5	283
		105.5	288
	Medium-coverage	102.5	273
		103.5	278
		*107.5	298

MELBOURNE

Existing:	3MBS-FM	93.7	229	(not complying (with siting (requirement. For (station limited to (3kW on existing (site & frequency. (3MBS-FM).
Existing:	3ABC-FM	105.7	289	
Existing:	RMIT	102.7	274	
Proposed:	ABC 2nd Service (Frequency determined by A.B.C.B.)	104.7	284	
Proposed:	Medium Coverage	103.7	279	
		*106.7	294	
		*107.7	299	
	(Note 1)*	92.7	224	(possibly change to (92.9 to allow 92.1 (for WC co-sited (or MC co-sited.

BRISBANE

Existing:	4ZZZ-FM (Queensland University Union)	102.1 DA	271	(temporary alloca- (tion - 105.7 MHz. (See Note 2.
Proposed:	Wide Coverage	106.1	291	
		105.1	286	
	Medium Coverage	103.3	277	
		104.1	281	
		*107.1	296	
	(Note 1)*	92.7	224	

ADELAIDE

Existing:	5ABC-FM	92.1	221	
Proposed:	Wide Coverage	104.5	283	(may interfere with (Pt. Lincoln Ch.5 (TV translator.
		105.5	288	
	Medium Coverage	102.3	272	
		103.3	277	
		*106.3	292	
		*107.1	296	
		*107.9	300	

PERTH			
Existing:	W.A. University	92.1 DA	221
Proposed:	Wide Coverage	97.5	248
	(Note 3)	98.5	253
	Medium Coverage	95.5	238
		96.5	243
	(Note 4)	* 93.5	228
HOBART			
Existing:	Tasmania CAE	92.1	221
Proposed:	Wide Coverage	93.1	226
		93.9	230
	Medium Coverage	103.3	277
		104.3	282
		*102.3	272
Major Cities			
NEWCASTLE			
Existing:	Newcastle University	103.9	280
Proposed:	Wide Coverage	106.1	291
	Medium Coverage	*106.9	295
		*107.9	300
		*101.5	268
WOLLONGONG			
Existing:	nil		
Proposed:	Wide Coverage	106.3	292
	Medium Coverage	102.9	174
		*101.1	266
LAUNCESTON	(Note 5)		
Proposed:	Wide Coverage	105.5	288
	Medium Coverage	103.7	279
		*102.7	274

* extra channels allocated outside national plan.

DA directional aerial.

2. Other Areas - Proposed Wide-Coverage Channels

NEW SOUTH WALES

District	Site	Nearest Town	Freq-uency	Ch.No.	
Richmond-Tweed	Mt. Nardi	Lismore	104.5	283	
Grafton-Kempsey	Mt. Moombil	Dorrigo	105.1	286	
Upper Namoi	Mt. Dowe	Narrabri	105.5	288	
Central Western Slopes	Mt. Cenn-Cruaich	Coonabara-bran	106.3	292	
Manning River	Middle Brother	Taree	105.7	289	
Central Tablelands	Mt.Canobolas	Orange	105.1	286	
Murrumbidgee Irrigation area	Mt. Bingar	Griffith	106.3	292	
Illawarra	Knights Hill	Dapto	106.3	292	
South-Western Slopes	Mt. Ulandra	Coota-mundra	105.5	288	
Bega-Cooma	Brown Mountain	Bega	106.1	291	

VICTORIA

Upper Murray	Mt.Baranduda	Wodonga	105.9	290	
Goulburn Valley	Mt. Major	Shepparton	105.1	286	
Bendigo	Mt.Alexander		106.3	292	(Note 6)
LaTrobe Valley	Mt. Tassie	Traralgon	106.3	292	" "
Murray Valley	Goschen	Swan Hill	105.9	290	
Mildura	Yatpool		104.7	284	
Ballarat area	Lookout Hill	Beaufort	105.3	287	

QUEENSLAND

Cairns	Mt.Bellenden-Ker	Babinda	106.1	291	
Townsville	Mt. Stuart		105.7	289	
Mackay	Mt. Blackwood		105.3	287	
Rockhampton	Mt. Hopeful	Mt. Morgan	104.9	285	
Wide Bay	Mt.Goonaneman	Childers	104.7	284	
Darling Downs	Mt.Mowbullan	Dalby	104.5	283	
Southern Downs	Passchen-daele Ridge	Stanthorpe	105.7	289	

SOUTH AUSTRALIA

District	Site	Nearest Town	Frequency	Ch.No.
Spencer Gulf North	The Bluff	Port Pirie	104.9	285
Central East	Loxton		105.1	286
South East	Mt. Burr	Millicent	104.9	285

WESTERN AUSTRALIA

+ Geraldton	9.7 km NE of Geraldton	97.7	249
+ Morawa	Billeranga Hills	98.3	252
+ Moora	Quarrell Range	97.9	250
Central Agricultural	Mawson	99.1	256
Bunbury	Mt. Lennard	97.9	250
Southern Agricultural	Mt. Barker	98.3	252
+ Kalgoorlie	6.4 km NW of Kalgoorlie	98.1	251

+ These stations are located at sites occupied by medium power TV stations. To provide complete coverage of the appropriate districts by the ABC programme, high power FM channels have been allocated. The allotted frequencies may be used for medium coverage transmissions if desired.

3. Other areas (Provincial Cities and Towns) - Proposed Medium Coverage Channels

NEW SOUTH WALES

Albury	104.3	282	
Armidale	103.9	280	Existing 92.3 MHz, Ch. No. 222 New England University
Bathurst	103.1	276	Existing 92.3 MHz, Ch. No. 222 Mitchell College of Advanced Education.
Bowral	104.1	281	
Broken Hill	102.3	272	
Coffs Harbour	104.1	281	
Cooma	103.3	277	

Cootamundra	104.1	281	
Cowra	102.7	274	
Deniliquin	102.1	271	
Dubbo	102.1	271	
Forbes/Parkes	103.3	277	
Glen Innes	102.5	273	
Goulburn	103.3	277	
Grafton	103.3	277	
Griffith	103.7	279	
Gunnedah	103.7	279	
Gosford			(Note 7)
Inverell	103.5	278	
Katoomba	102.1	271	
Kempsey	103.5	278	
Leeton	102.3	272	
Lismore	102.3	272	Existing 92.5 MHz, Ch. No. 223 Northern Rivers College of Advanced Education.
Moree	103.1	276	
Mudgee	104.1	281	
Muswellbrook	103.5	278	
Narrabri	102.7	274	
Nowra	102.3	272	
Orange	103.7	279	
Port Macquarie	102.1	271	
Tamworth	103.3	277	
Taree	102.7	274	
Wagga Wagga	103.5	278	
Wellington	102.9	275	
Young	102.3	272	

VICTORIA

Bairnsdale	103.9	280
Ballarat	104.1	281
Colac	102.5	273
Echuca	103.9	280
Geelong	102.1	271
Hamilton	103.7	279
Horsham	102.1	271
Maryborough	103.5	278

Mildura	102.5	273	
Morwell (Note 9)	104.3	282	Existing 103.5 Gippsland College of Advanced Education Churchill, also temp. 107.1 Traralgon 107.9 Moe relays.
Mt. Alexander	102.3	272	(Bendigo & Castlemaine area)
Mt. Major	102.5	273	(Shepparton & Benalla area)
Portland	102.3	272	
Sale	102.5	273	
Seymour	103.3	277	
Stawell/Ararat	102.7	274	
Swan Hill	102.7	274	
Wangaratta	103.7	279	
Warragul	102.3	272	
Warrnambool	103.3	277	

QUEENSLAND

Ayr	103.5	278	
Bowen	102.7	274	
Bundaberg	103.7	279	
Cairns	103.7	279	
Charters Towers	103.7	279	
Dalby	102.3	272	
Gladstone	102.5	273	
Gold Coast	103.7	279	
Gympie	103.9	280	
Ingham	102.5	273	
Innisfail	103.3	277	
Kingaroy	103.5	278	
Mackay	102.3	272	
Mareeba	102.1	271	
Maryborough	102.3	272	
Nambour	102.5	273	
Rockhampton	102.1	271	
Roma	102.1	271	
Toowoomba	102.7	274	
Townsville	102.1	271	
Warwick	103.9	280	

SOUTH AUSTRALIA

Gawler	104.3	282	(usable anywhere in the area between Elizabeth and the Barossa Valley)
Mt. Gambier	104.1	281	
Murray Bridge	103.9	280	(usable anywhere in Murray Bridge -Monarto district)
Naracoorte	103.7	279	
Peterborough	102.9	275	
Port Augusta	102.1	271	
Port Lincoln	104.1	281	
Port Pirie	102.5	273	
Renmark	103.5	278	
Victor Harbour	102.7	274	
Wallaroo	103.7	279	
Whyalla	103.3	277	

WESTERN AUSTRALIA

Albany	95.7	239	
Bunbury	95.1	236	
Busselton	96.1	241	
Collie	96.5	243	
Esperance	96.9	245	
Geraldton	95.1	236	
Kalgoorlie	95.5	238	
Katanning	95.9	240	
Mandurah	96.9	245	
Manjimup	95.5	238	
Merredin	95.7	239	
Moora	95.3	237	
Narrogin	95.3	237	
Norseman	96.7	244	
Northam	95.1	236	
York	95.9	240	

TASMANIA

Burnie	103.3	277	
Devonport	104.1	281	
New Norfolk			(Note 7)

NORTHERN TERRITORY (Note 8)

Darwin	104.1	281
	93.9	230
Alice Springs	104.3	282
	102.1	271
Katherine	104.5	293
	106.5	292
Tennant Creek	104.7	284
	93.7	229
Gove	104.9	285
	93.5	228

NOTES

1) A medium coverage station allocated this frequency should be co-sited with the TV transmitters serving the area, and will in general be required to use a directional aerial to ensure that its signal covers only its intended service area.

2) The use of the channels allocated in the Brisbane area is dependent on the prior change of the Toowoomba TV translator from channel 5. Hence the temporary allocation of 105.7 MHz to 4ZZZ-FM.

3) Perth and southern W.A. allocations are based on Mawson ABCW-4 TV being moved to provide frequency space for the Stage 1 of FM development.

4) A station using the frequency of 93.5 MHz should be co-sited with the TV transmitters to minimise interference to reception of TV signals.

5) To minimise interference to or from mainland services, the northern Tasmania transmitters may need to use directional aerials. In Stage 2 of FM development, the northern Tasmania services should be re-allocated frequencies that do not clash with those of mainland stations.

6) The wide-coverage stations on Mt. Alexander and Mt. Tassie may require directional aerials to avoid mutual interference.

7) The channels allotted to Gosford (NSW) and New Norfolk (Tas.) are unavailable as a result of the additional channels allocated in Newcastle and Hobart respectively. Interim low coverage services for Gosford and New Norfolk could be allocated frequencies in TV channel 4 if the additional channels in Newcastle or Hobart are taken up and services in Gosford or New Norfolk are required before Stage 2 of FM development.

8) Although allocated as medium coverage services, the channels listed may be used for wide, medium or low coverage stations as required.

9) May result in intermodulation interference to GLV-10 via 106.3 MHz allocated to LaTrobe Valley wide coverage service - should be eliminated by a trap on the TV receiver. If necessary, re-allocate one of these services when TV channel 3 or 4 is cleared for FM.

APPENDIX

INTERFERENCE FROM FM STATION 3MBS TO TELEVISION SERVICES

1. In July, 1973 as part of its parallel studies of possible VHF and UHF FM broadcasting services, the A.B.C.B. published Engineering Report No. 34, which summarised interactions known or predicted to occur between VHF television services and FM transmissions in the 88-108 MHz band.

   This report was based on theoretical studies and laboratory work.

2. Apart from the interference to be expected between services with adjacent or overlapping spectrum occupancy, which is well documented on an international basis, another form of interaction was observed experimentally in a substantial minority of the Australian TV receivers tested. Interference to the reception of certain TV channels was found to be produced by strong FM signals at frequencies half those of parts of the TV channel involved, even though the harmonics of the FM transmission were thoroughly filtered to a negligible level. The mechanism is believed to be the generation of the second harmonic by non-linearity in the first stage of the TV receiver. This harmonic falls within the TV channel and produces a visible or audible beat with components of the TV transmission.

3. The interference was demonstrated to the Commissioners of the Independent Inquiry into FM Broadcasting, led by Sir Francis McLean; however they preferred to rely on the evidence of European experts who advised that no such problems had arisen there; the report of the Inquiry (Appendix 7) discounted the evidence presented, stating that "much of the interference to TV reception forecast in Report No. 34 was not a limitation in practice".

   The circumstance disregarded in this judgement was the difference in performance of the population of 3 million Australian TV receivers from that of receivers of European manufacture. The two populations of receivers were manufactured under conditions which differed in two respects:

   (a) European TV receivers were developed in the presence of an extensive network of FM transmissions, so that any interference from FM would be immediately evident and eliminated during the design phase. There have been no services other than TV in the 88-108 MHz band in Australia during the period that locally-made TV receivers have been designed and marketed, so that protection against FM interference has not been a requirement.

   (b) Australian TV receivers have to be designed for full sensitivity in the 88-108 MHz band, in order to receive Channels 3, 4 and 5.

European receivers have no such requirement and are in many cases deliberately desensitised to avoid FM interference problems.

The fact that a proportion of Australian TV receivers was found in laboratory investigations to be susceptible to FM interference is therefore not surprising.

4. In 1974 the Postmaster-General of the day licensed subscription-financed classical music FM stations in Sydney and Melbourne in that part of the 88-108 MHz band (92-94 MHz) lying between TV channels 3 and 4, and not at that time, under the control of the A.B.C.B. The Melbourne station 3MBS was authorised to operate from the Kew site it had proposed, with adequate power (10 kilowatts e.r.p.) to provide satisfactory metropolitan coverage.

In 1975 after the stations had been established, control of the 92-94 MHz band was transferred to the A.B.C.B., but because the Broadcasting and Television Act gave no power to licence such stations as 3MBS until amended, licensing of these subscription stations has continued under the Wireless Telegraphy Act, now administered by the Postal and Telecommunications Department.

5. Unfortunately the whole of the 92-94 MHz band is in second harmonic relationship to television channel 7, 181-188 MHz, and experimental evidence suggested that interference to reception of television channels 0 and 7 would occur when FM transmissions in the band 92-94 MHz were radiated from a site in close proximity to television receivers. For this reason the radiated power of 3MBS-FM was increased in a series of steps, while the incidence of interference was monitored by Board, A.T.C. and M.B.S. observers.

Station 3MBS-FM commenced regular transmissions in July 1975, on a frequency of 92.5 MHz. During the early, low power transmissions, very few reports of television interference were received. However, an increase in radiated power from 1kW to 4kW (approximately), produced a steep increase in the number of interference complaints being received. With the power level maintained at the 4kW level, a door to door survey was conducted in three areas to the west of the 3MBS-FM transmitter; at distances of approximately 0.4 km., 0.8 km. and 1.5 km. The general direction and particular areas were chosen to provide a sample based on "worst-case" conditions. The survey, which included visits to 156 homes, yielded information on 123 television receivers. Of these receivers, 19.5% suffered noticeable interference to reception of either Channel 0 or Channel 7 (12% suffered sévere interference); 17% suffered interference to Channel 0; 4% suffered interference to Channel 7. Only nine of the receivers included in the survey were colour receivers; of these, five suffered interference to Channel 0 only, one suffered interference to Channel 0 and Channel 7.

The receivers suffering interference were not restricted to any particular brand, model, or to any particular age. In no instance had the interference problem been reported to the A.B.C.B., A.T.C., P. & T. Department, the Television Stations or to 3MBS-FM.

On October 11th, 1975, following a request from the A.B.C.B., station 3MBS-FM changed frequency and began transmitting on its present allocation of 93.7 MHz, at an effective radiated power of approximately 4kW. Tests carried out in the Board Laboratory, and subsequent inspection of television receivers at addresses where interference had been detected during the previous survey, indicated that the change in frequency had reduced the level of interference caused to reception on monochrome receivers, but may have caused the interference produced on colour receivers tuned to Channel 0 to become more objectionable.

The original interference manifested itself in the form of fine herringbone patterns or coarse grain-like video noise, with some television receivers having their audio channel "captured" by 3MBS-FM signals when tuned to Channel 7. Since 3MBS-FM changed frequency, the intensity of the interference pattern has generally been reduced, but it now takes the form of a very coarse herringbone pattern which is more annoying than the previous pattern, particularly on colour receivers tuned to Channel 0.

Officers of the Engineering Division of the Board have investigated approximately fifty reports of television interference caused by 3MBS-FM, of these slightly over fifty per cent were found to be due to FM interference. It was found that, in all genuine cases, the interference could be eliminated by fitting a simple filter to the television receiver input terminals - provided that the receiving installation (including mast-head amplifiers and distribution system where applicable) was in good order. These filters, which serve to attenuate the unwanted FM signal, are of two types:-

(a) An open-circuited quarter-wave stub, consisting of approximately 680 mm of ordinary television ribbon feeder, is attached to the same terminals as the aerial feeder ribbon. The material cost of this filter is low, but in most cases it must be adjusted by a technician. In service it tends to be inconvenient because it hangs outside the receiver and its performance is affected by its proximity to other objects.

(b) A lumped-component filter, consisting of an air-cored inductance and an adjustable capacitor, mounted together in a plastic or metal box. Available in two forms, this filter is either attached to the same terminals as the aerial feeder ribbon or, in the case of a co-axial

aerial feeder, is fitted with appropriate plugs and connected between the aerial feeder and the aerial socket on the receiver. This type of filter would be more expensive to manufacture but is easily adjusted and its performance is relatively independent of its surroundings.

Although the operation of 3MBS-FM in Kew has confirmed that interference will be caused to local television reception when medium power FM signals are radiated in the band 92-94 MHz from a site within the coverage area but remote from the television transmitters, the investigation carried out by the Engineering Division has revealed that, with the compromise adopted in which 3MBS has been moved to that frequency (93.7 MHz) within the 92-94 MHz found to cause least interference to TV reception, and operated at 3-4 kilowatts e.r.p. giving it just adequate metropolitan cover:-

(a) The interference is neither widespread nor general, but confined to about 20% of TV receivers within 1 km. of the FM transmitter site.

(b) A simple filter fitted to the television receiver input terminals will attenuate the FM signal sufficiently to eliminate the interference, by desensitising the receiver to transmission in a broad band centred near 93 MHz.

6. Now that the band 101-108 MHz has been cleared for FM use in the Melbourne area it would be possible to allocate a frequency in this band to 3MBS which would permit operation at 10 kilowatts e.r.p. without appreciable interference to TV reception; however this would involve major upheaval and expense in completely rebuilding transmitter and transmitting aerials, which would be a major difficulty for a non-profit-making society dependent for capital and revenue on subscriptions from its members.

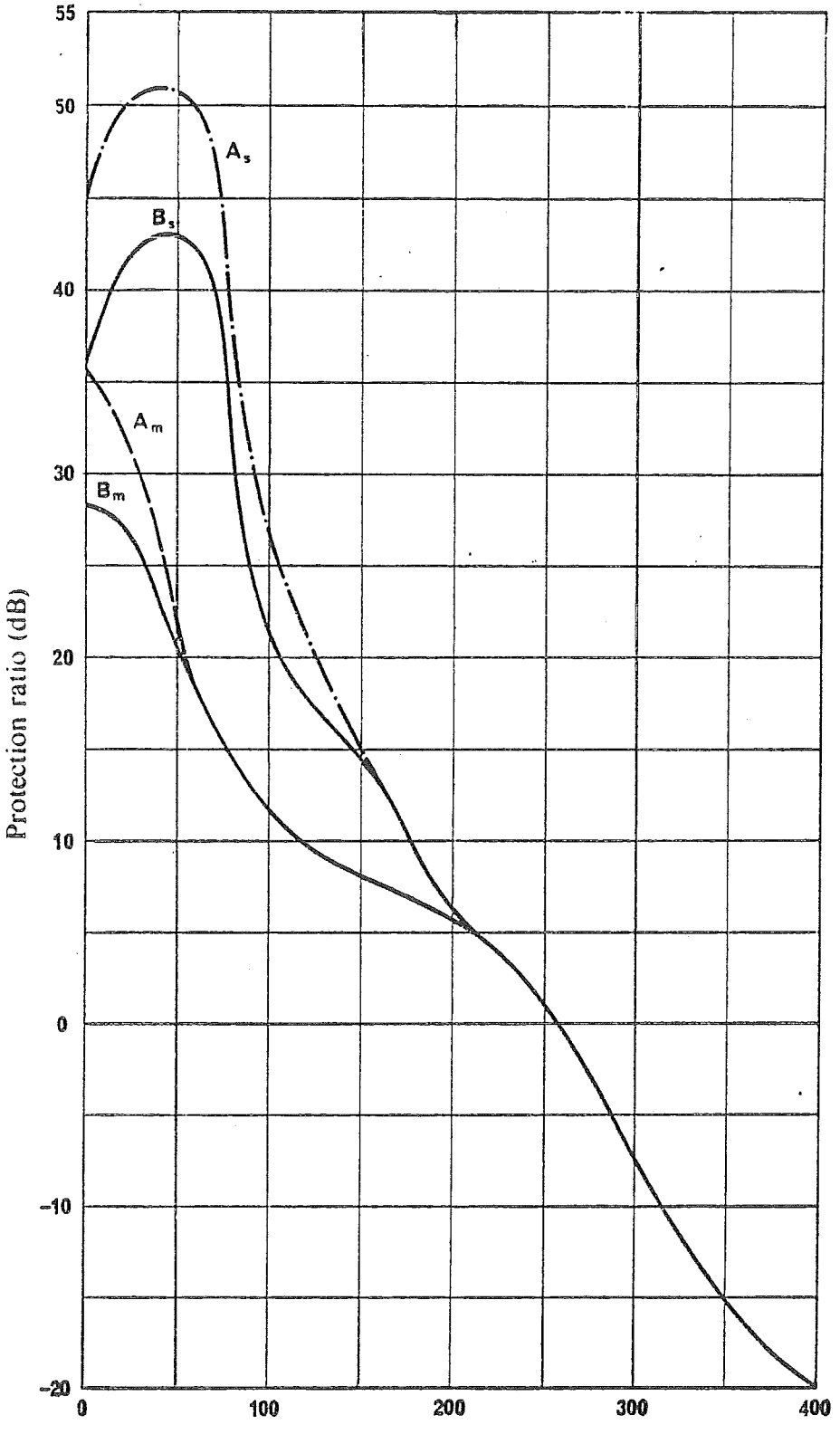

FIGURE 1

Protection ratios required by VHF broadcasting services at frequencies between 87·5 MHz and 108 MHz using a maximum frequency deviation of ± 75 kHz

Curve A_s : stereophonic broadcasting—steady interference
Curve B_s : stereophonic broadcasting—tropospheric interference (99% of the time)
Curve A_m: monophonic broadcasting—steady interference
Curve B_m: monophonic broadcasting—tropospheric interference (99% of the time)

(after C.C.I.R.)

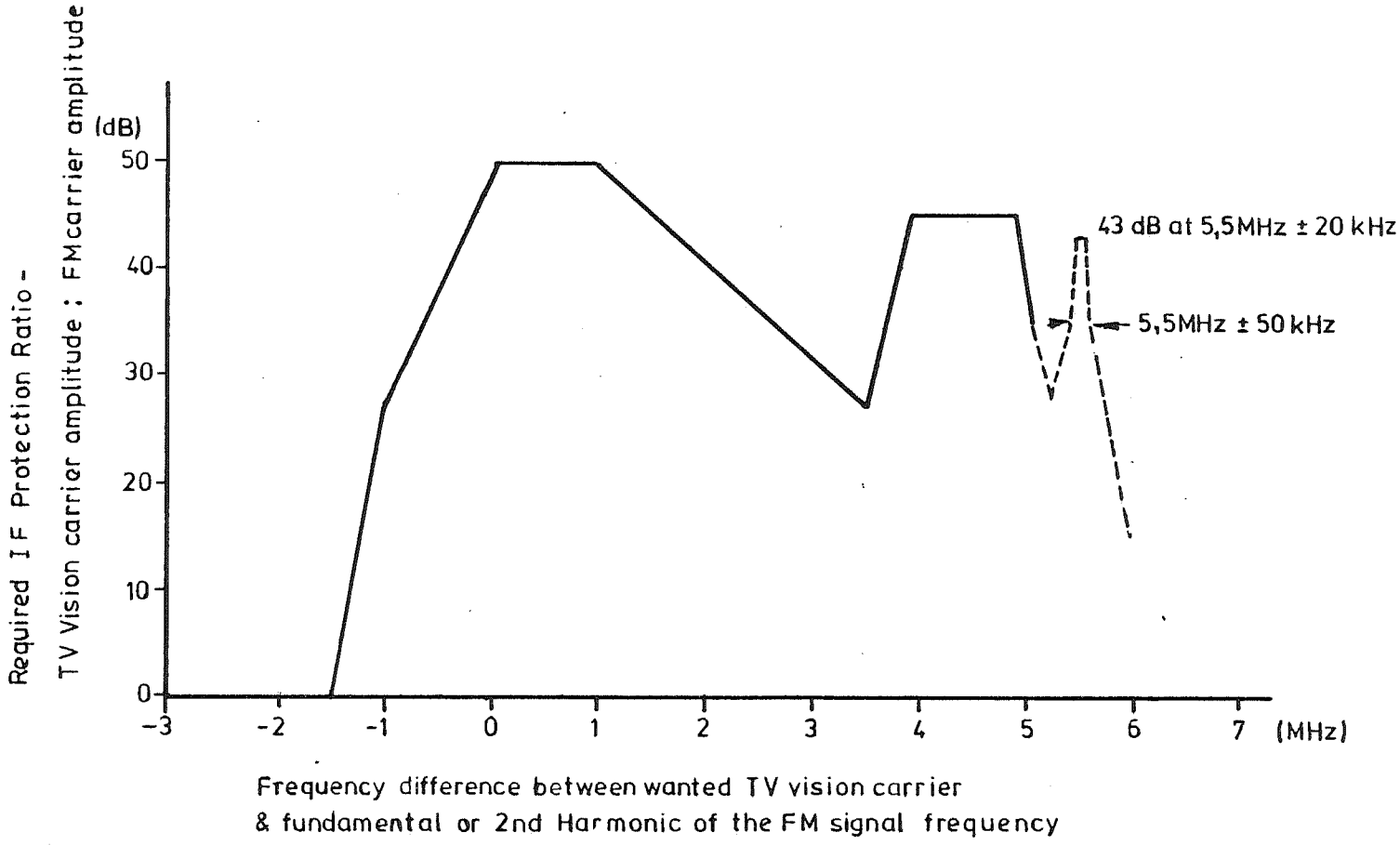

Fig 2 TV Receiver IF Protection ratio required to avoid FM Interference to TV service

(after C.C.I.R.)

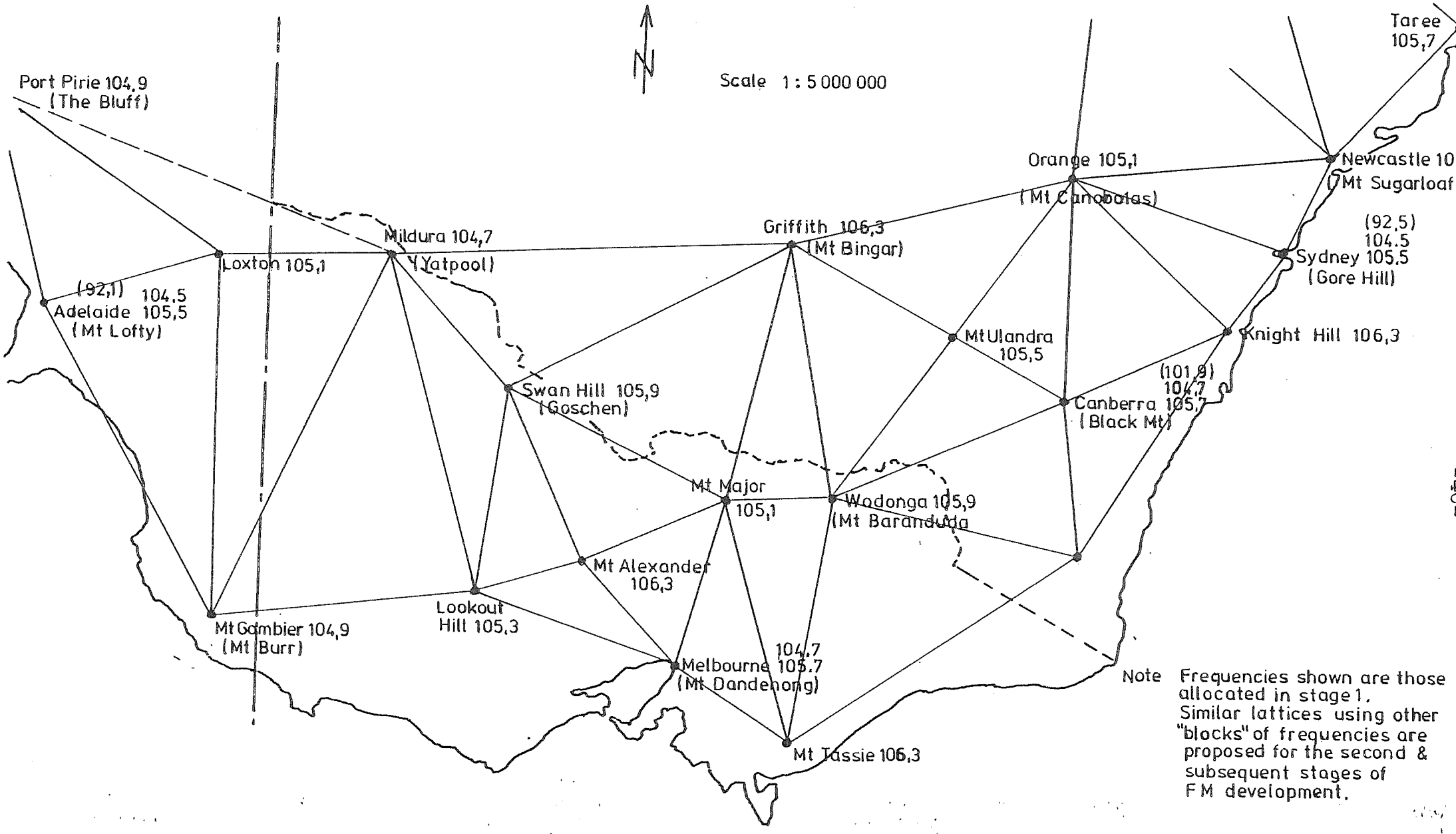

Fig 3: Part of lattice frequency plan for Wide Coverage F M transmitter sites

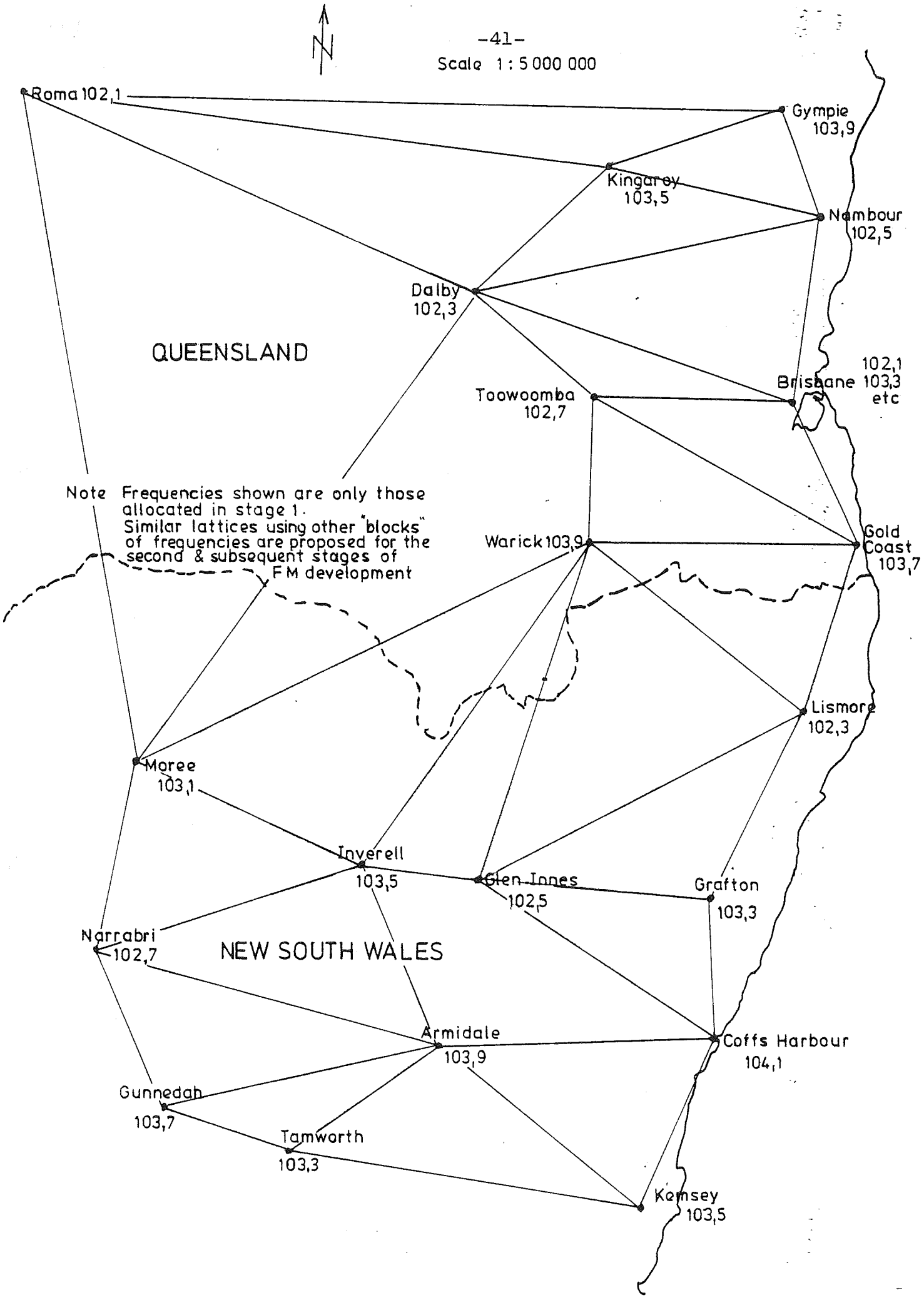

Fig 4: Part of medium coverage station plan for medium coverage FM stations - Stage 1