Appendix B Victorian hydrological regions for sizing stormwater treatment measures

Contents

B.1 Introduction

Achievable treatment objectives for stormwater quality have been defined in Victoria and New South Wales. These objectives are expressed in reductions to be gained in the mean annual pollutant loads discharged from typical urban areas with no stormwater treatments installed (e.g. 80% reduction in Total Suspended Solids, TSS, and 45% reduction in Total Phosphorus, TP, and Total Nitrogen, TN). A range of stormwater treatment measures are capable of treating urban stormwater to meet the treatment objectives stated. The design of stormwater treatment measures often requires a continuous simulation approach to properly consider the influence of antecedent conditions of the treatment measure during a storm event and the wide range of storm characteristics and hydraulic conditions that the individual treatment measures are to operate in. Computer models such as the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) (CRCCH 2002) developed to enable continuous simulations of complex stormwater management treatment trains aid in the development of stormwater management strategies and the design (sizing) of stormwater treatment measures.

This Manual builds upon earlier work (described in *Hydrologic Regions for Sizing of Stormwater Treatment in Victoria*, October 2003) and its purpose is to develop an alternative, simpler design procedure that can be used in small development projects (e.g. single or a small clustered allotment development type) and could serve as a preliminary design procedure. In addition the procedure could be used as a simple design checking tool. An example of a similar tool is the one developed in the Association of Bayside Municipality (ABM) project (where a design chart containing the expected performance of several typical stormwater treatment measures were developed for the Melbourne metropolitan region (Figure B.1).

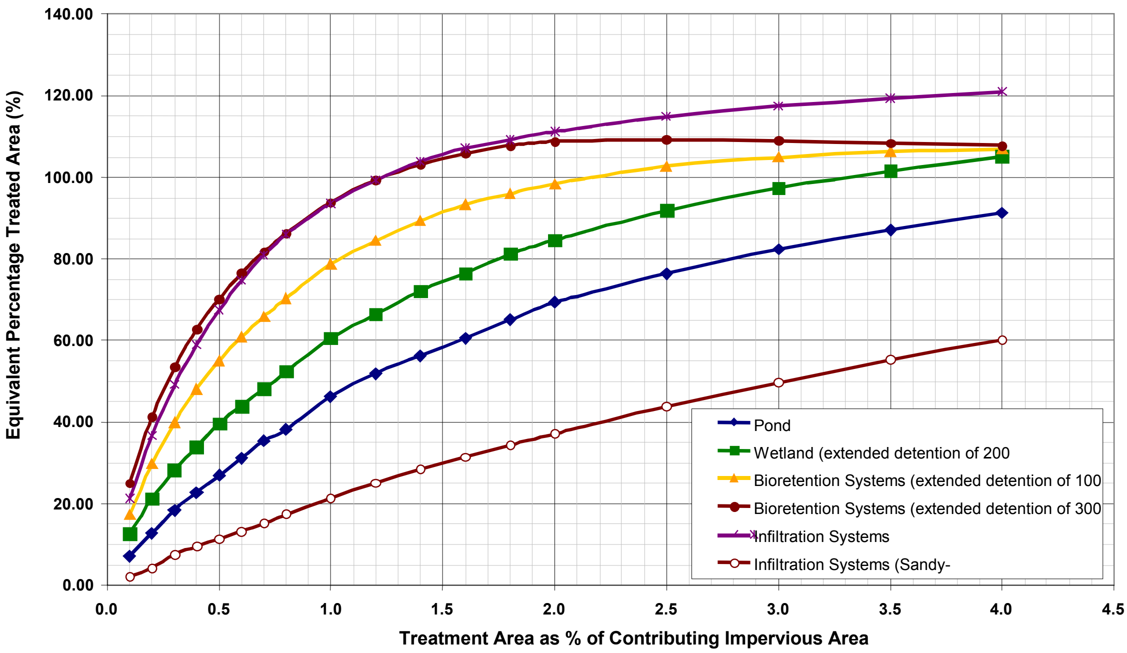

Figure B.1.1 Equivalent Percentage Treated Area (EPTA) chart developed for the Association of Bayside Municipalities. (EPTA is the percentage of impervious area treated to meet Victorian best practice environmental management objectives for urban stormwater.)

It was envisaged that a simple procedure such as the one developed for the ABM project could be developed for all regions in Victoria. Sizing stormwater treatment systems could be based around defining simple empirical design equations that would be applicable in their respective designated hydrologic region within Victoria. This Manual presents results of developing the empirical relationships and the number of regions.

B.2 Methodology

After initial consideration of possible design approaches, the following was used to develop the different regions and adjustment factors for sizing stormwater treatment measures throughout Victoria:

1. A rating was selected to represent the effectiveness of different design configurations of various stormwater treatment measures. Reduction in total nitrogen was a logical choice as it is commonly the limiting parameter in meeting best practice stormwater quality objectives.

2. A reference site was selected for which detailed investigation and design simulations were undertaken to determine the relationship between design configurations (e.g. area, extended detention depth, permanent pool and volume) of a range of stormwater treatment measures and the corresponding improvement in stormwater quality performance. Melbourne was a logical choice and was selected as a reference site.

3. Hydrologic regions were defined within Victoria where practitioners wanting to design stormwater treatments could measure any location in Victoria, refer to the design requirements developed for the reference site (i.e. Melbourne) and apply an adjustment factor to that size to determine the appropriate dimensions of the treatment measure for their particular site.
   For example, in order to meet best practice objectives, a wetland in the Melbourne region must be at least 2% of the contributing impervious area of its catchment. A practitioner designing a wetland of similar configuration in Mildura can simply use an empirical equation to calculate the adjustment factor that is then applied to the size of a wetland sized for the reference site (i.e. Melbourne).

4. It was envisaged that several geographical and meteorological factors could influence the value of the adjustment factor. These include Mean Annual Rainfall (MAR), a measure of seasonal distribution of rainfall and raindays, site elevation and geographical location. Thus, it was expected that Victoria would need to be divided into several hydrologic regions for which empirical equations for determining the adjustment factor need to be derived. In determining the hydrologic regions and the corresponding adjustment factor equations, information on site characteristics need to be readily available from the Bureau of Meteorology (BOM). As such, the set of possible influencing factors that were investigated were limited to those that can be obtained from the BOM website (www.bom.gov.au).

B.3 Determining hydrologic regions

The hydrologic regions for Water Sensitive Urban Design (WSUD) in Victoria were determined by selecting a set of pluviographic stations with a sufficiently long record to enable continuous simulations of the performance of several stormwater treatment measures. A total of 45 stations were selected for analysis, 15 of which are concentrated around the Melbourne/Geelong Metropolitan region. These stations and their BOM rainfall district are shown in the Table B.3.1. Figure 3.1and 3.2 show the respective spatial locations of the selected stations according to their longitude and latitude bearings. The additional stations around Melbourne were considered important because of the expected development activity. There is more available data for this region which enables a finer representation of the climatic factors.

Table B.3.1 Pluviographic stations and Bureau of Meteorology (BOM) districts

BOM district	Stations
Wimmera South	Horsham Tottington Wartook
North Mallee	Mildura
South Mallee	Hopetoun
Lower North	Cobram Kerang
Upper North	Bendigo Tatura Dookie
Lower Northeast	Dartmouth
Upper Northeast	Bright Hume Reservoir Omeo
East Gippsland	Buchan Sarsfield East Combienbar Genoa Wroxham
West Gippsland	East Sale East Tarwin Noojee Yallourn
West Central	Bullengarook
Western Plains	Ararat Ballarat
West Coast	Casterton Weeaproinah Wyelangta Mortlake
West Central	Laverton Melton Werribee
East Central	Melbourne Airport Bundoora Essendon Airport Melbourne Croydon Upwey Narre Warren North Dandenong Carrum Downs Koo Wee Rup

As evident in Figures B.3.1 and B.3.2, the selected pluviographic stations are reasonably well distributed across Victoria to ensure sufficient coverage of the state and the metropolitan region. The MAR for the sites selected ranged from 290 mm to 1900 mm, covering the wide range of rainfall conditions experienced across the state.

Total nitrogen was selected as the measure for representing the effectiveness of various sized treatment devices. In an attempt to define the most suitable hydrologic region and corresponding predictive equations, the influence of the following factors were considered:

- MAR
- the ratio of mean summer raindays to mean winter raindays (as a measure of rainday seasonality)
- the ratio of mean summer rainfall to mean winter rainfall (as a measure of rainfall seasonality)
- site elevation.

Figures B.3.3–B.3.6 are plots of the various meteorological factors and site elevations for the 45 stations.

The MUSIC program was used to simulate the performance of wetlands, bioretention systems, vegetated swales and ponds to size these systems to meet best practice objectives. These sizes were then normalised against the sizes derived for Melbourne and expressed as the ratio of the size of the treatment area for Melbourne. This is thus the adjustment factor described in Step 3 in the methodology (see Section B.2).

Following extensive testing and analysis of the significance of the possible influencing factors described in the above list, it was determined that MAR was the most significant influencing factor with which it was possible to represent Victoria with five hydrologic regions (excluding the Melbourne/Geelong Metropolitan region) (Figure B.3.3). Within the Melbourne/Geelong Metropolitan region a further four regions were used to provide a finer delineation of the influence of climatic conditions on the adjustment factor. Boundaries of the hydrologic region were determined to represent the results of the analysis and be aligned such that they do not dissect major urban areas in Victoria or are aligned with municipal boundaries, as much as possible, in the Melbourne/Geelong Metropolitan area. The exceptions to this are in the Cities of Wyndham and Casey where the hydrologic regions are bounded by Skeleton Creek and Monash Freeway, respectively.

In three of the four hydrologic regions shown in Figure B.3.4, the adjustment factor can be well represented for each treatment device by a single value (i.e. independent of rainfall) with the fourth region (Central and North West Metropolitan) represented as a function of MAR. Inclusion of other factors such as rainday seasonality, rainfall seasonality and elevation did not appear to improve the estimation of the adjustment factors for the 45 pluviographic stations used in the analysis.

The five hydrologic regions for Greater Victoria and the stations used in this analysis are shown in the Table B.3.2.

Table B.3.2—Hydrologic regions for Greater Victoria

Region	Stations
Northern	Mildura Hopetoun Kerang Cobram Hume Reservoir (Wodonda) Tottington Bendigo Tatura Dookie
Western	Horsham Wartook Reservoir Ararat Prison Ballarat
South Coast	Casterton Mortlake Weearproinah Wyelangta Noojee Yallourn East Tarwin
Great Dividing Range	Bullengarook East Darmouth Reservoir Bright Omeo Buchan Post Office
Gippsland	East Sale Sarsfield East Combienbar Wroxham Genoa

The four hydrologic regions for the Melbourne/Geelong Metropolitan area and the stations used in this analysis are shown in Table B.3.3.

Table B.3.3—Hydrologic regions for the Melbourne/Geelong Metropolitan area

Region	Stations
South West	Geelong North Little River Werribee
Central and North West	Melbourne Airport Laverton Melton Bundoora Essendon Airport Melbourne
East	Croydon Upwey Narre Warren North
South East	Dandenong Carrum Downs Koo Wee Rup

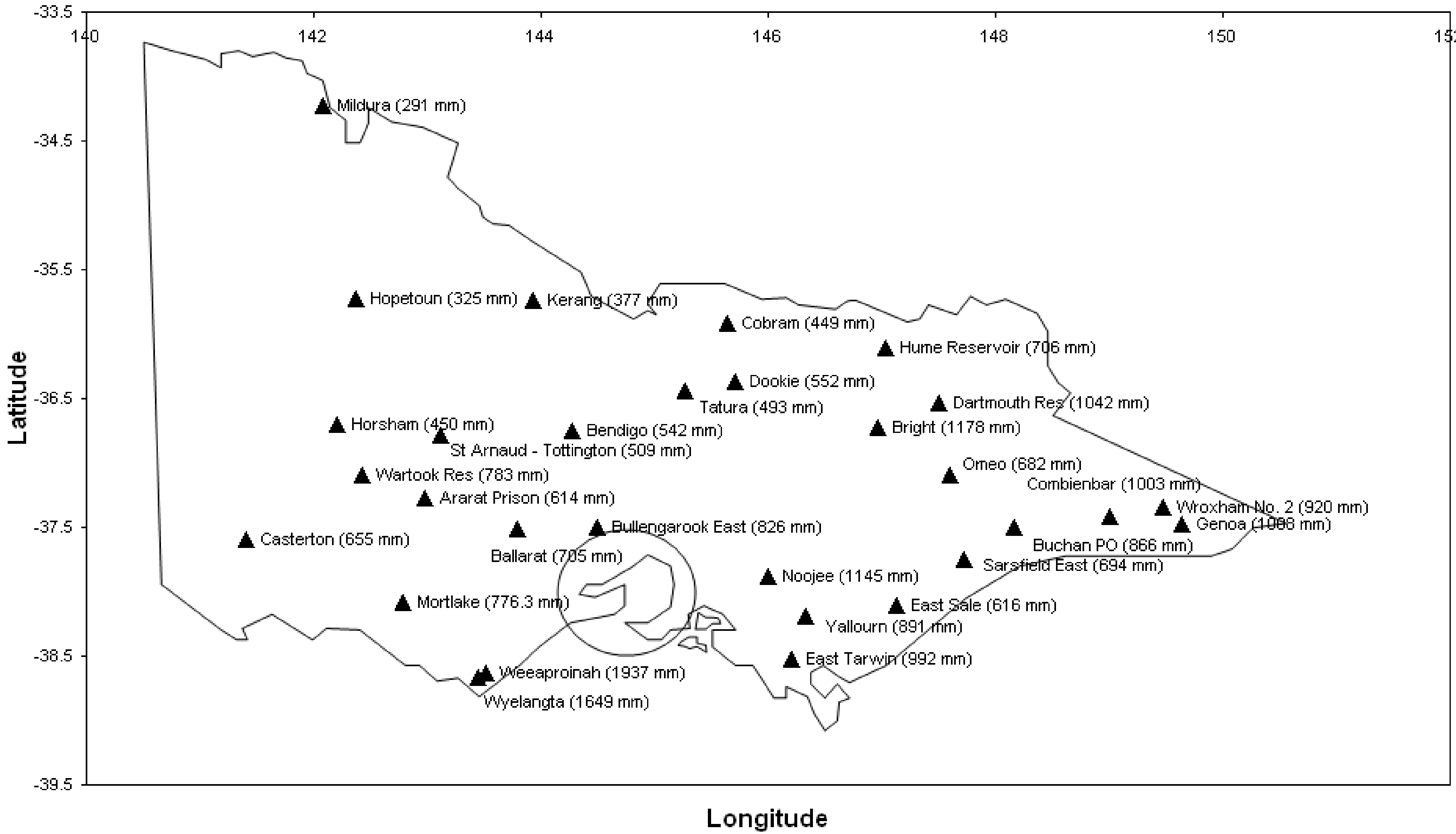

Figure B.3.1 Location of pluviographic stations in Greater Victoria used in defining hydrologic regions.

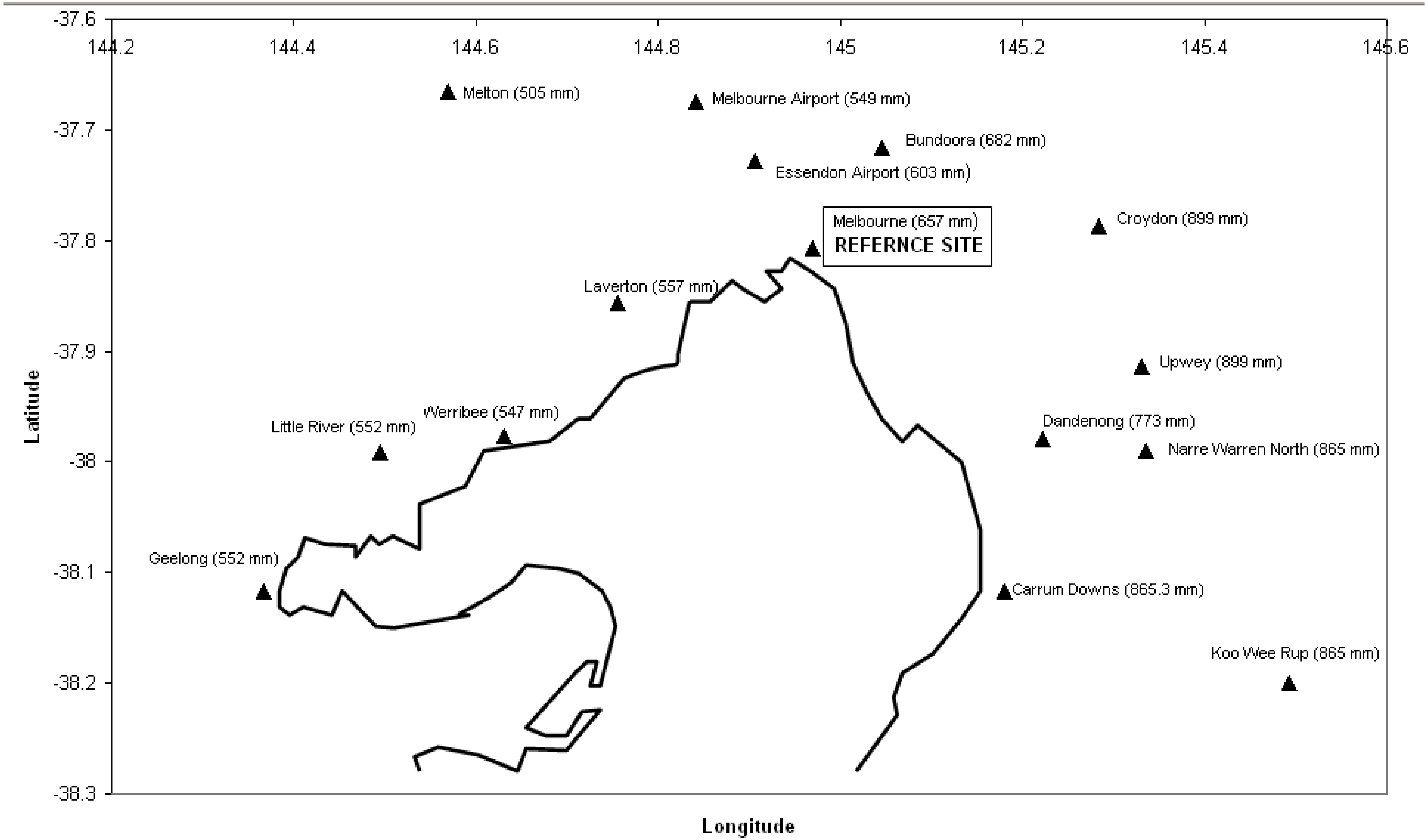

Figure B.3.2 Location of pluviograph stations in Melbourne/Geelong metropolitan region used to determine hydrologic regions.

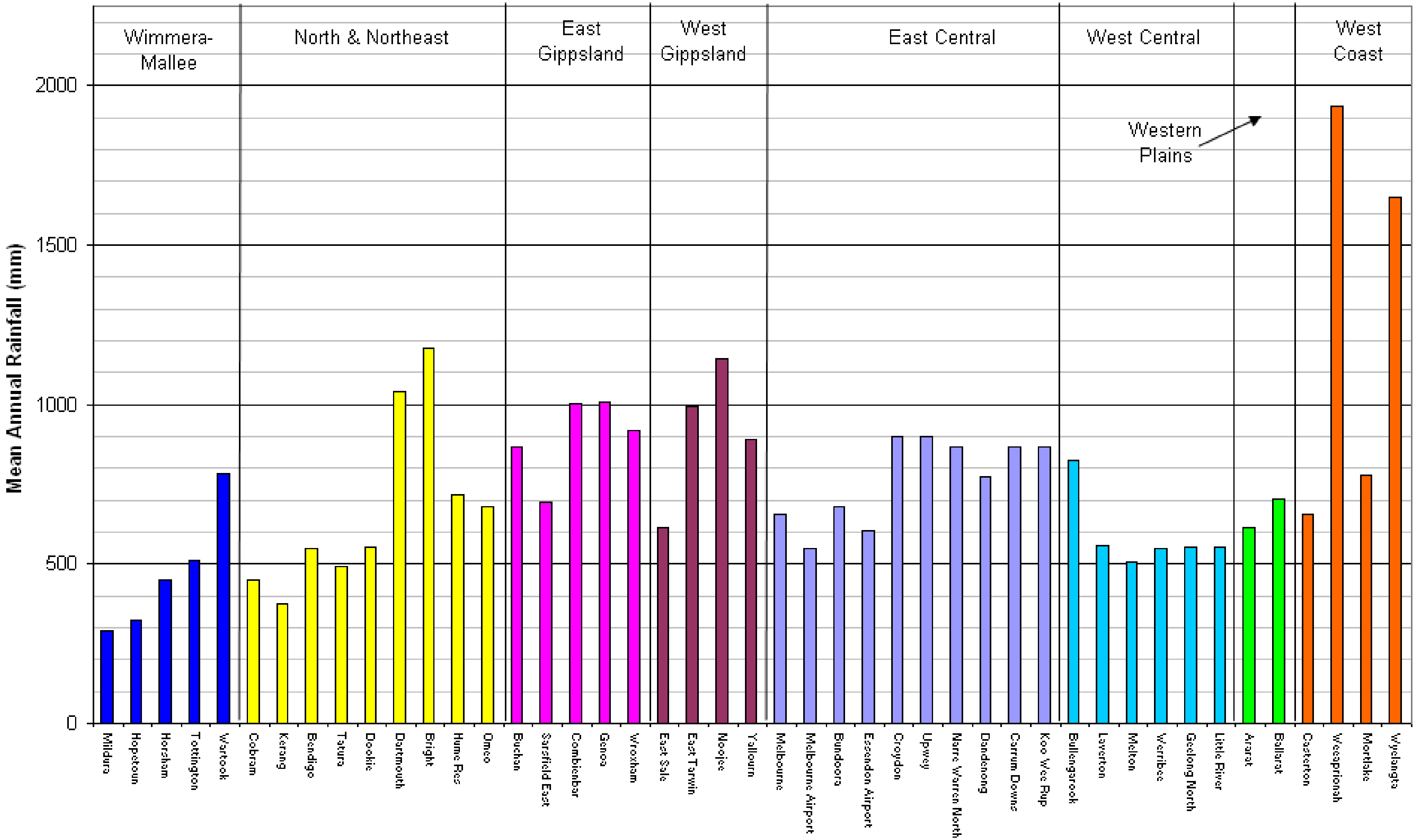

Figure B.3.3 Mean Annual Rainfall (MAR) at pluviograph station sites.

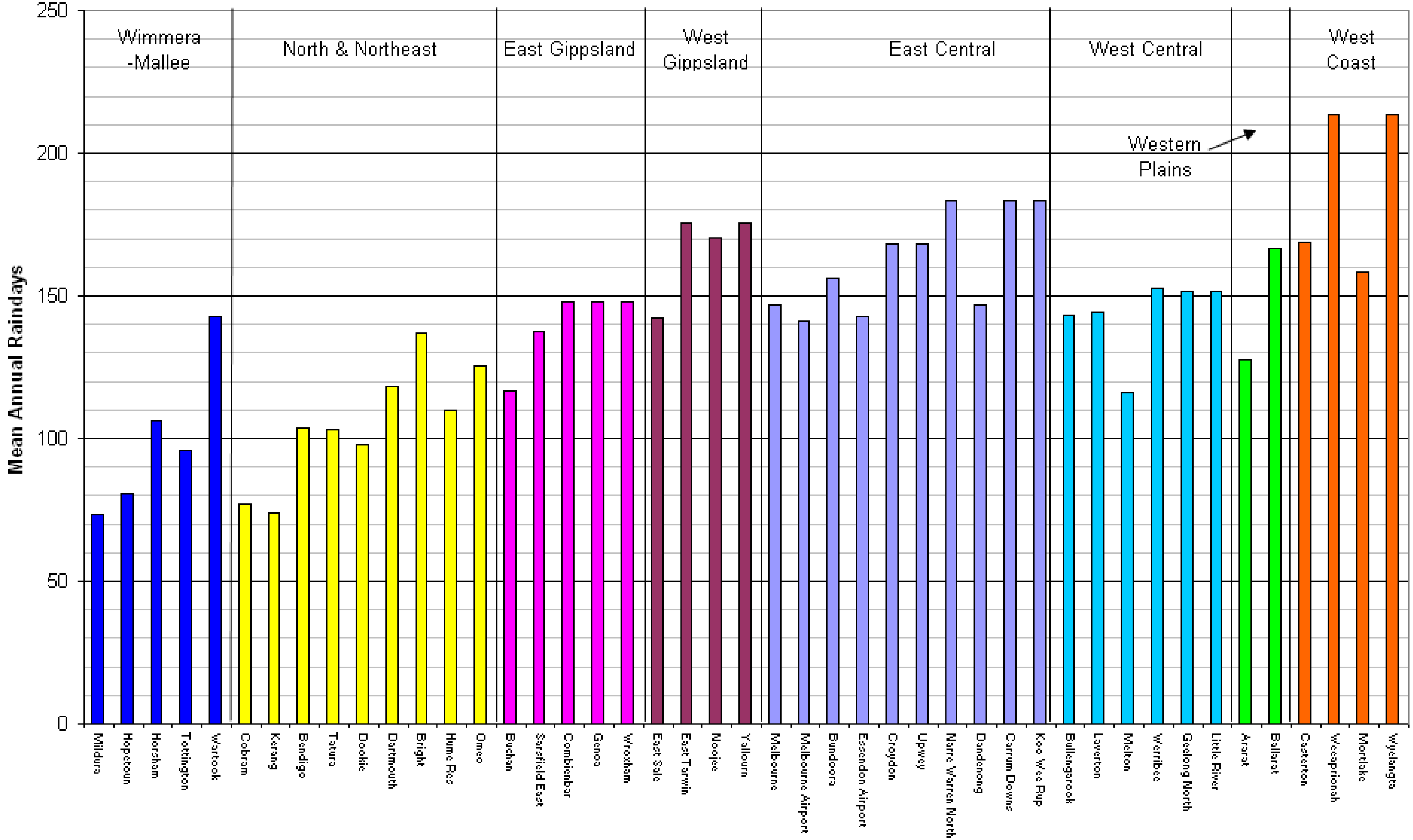

Figure B.3.4 Mean annual raindays at pluviographic station sites.

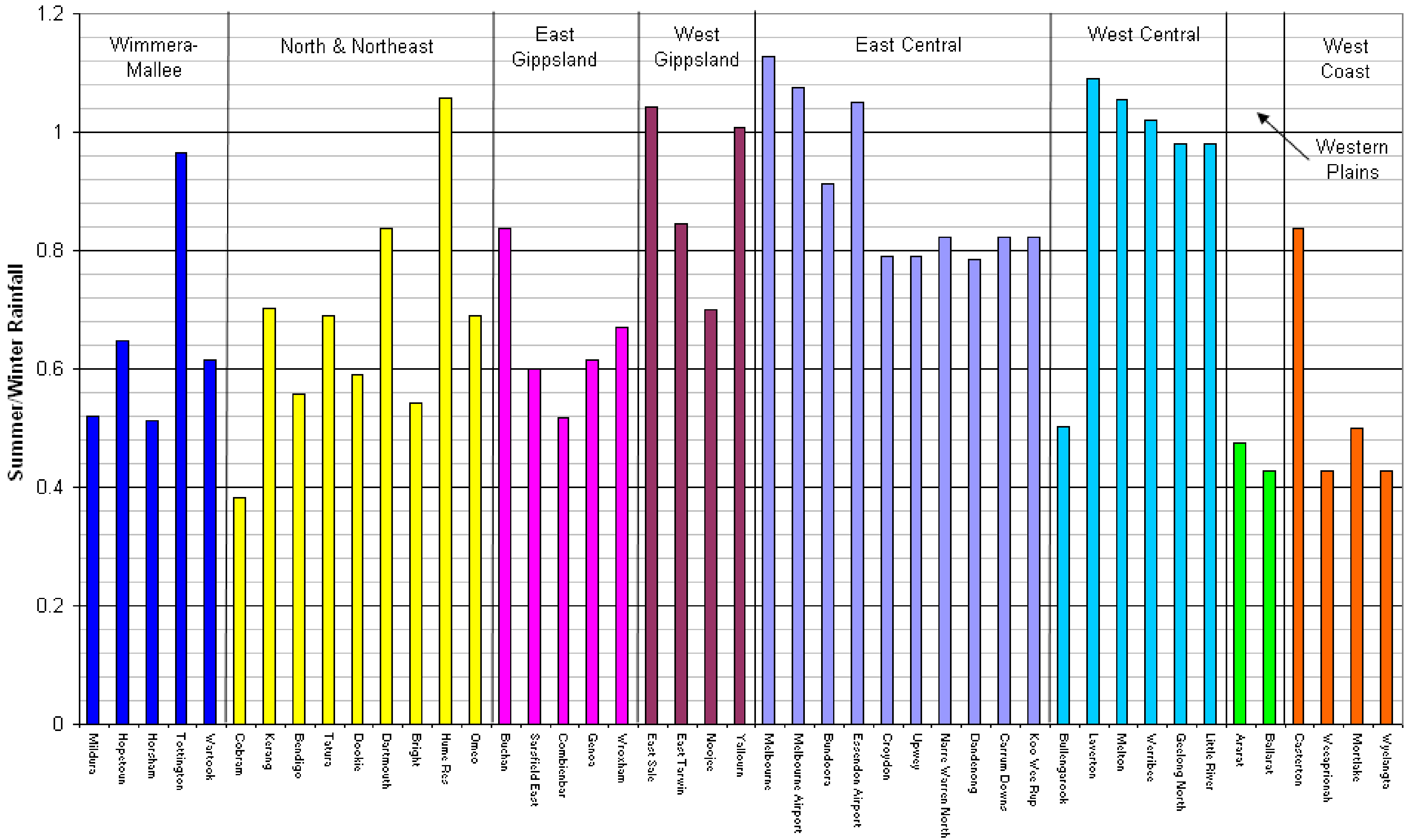

Figure B.3.5 Ratio of mean summer to mean winter rainfall at pluviographic station sites.

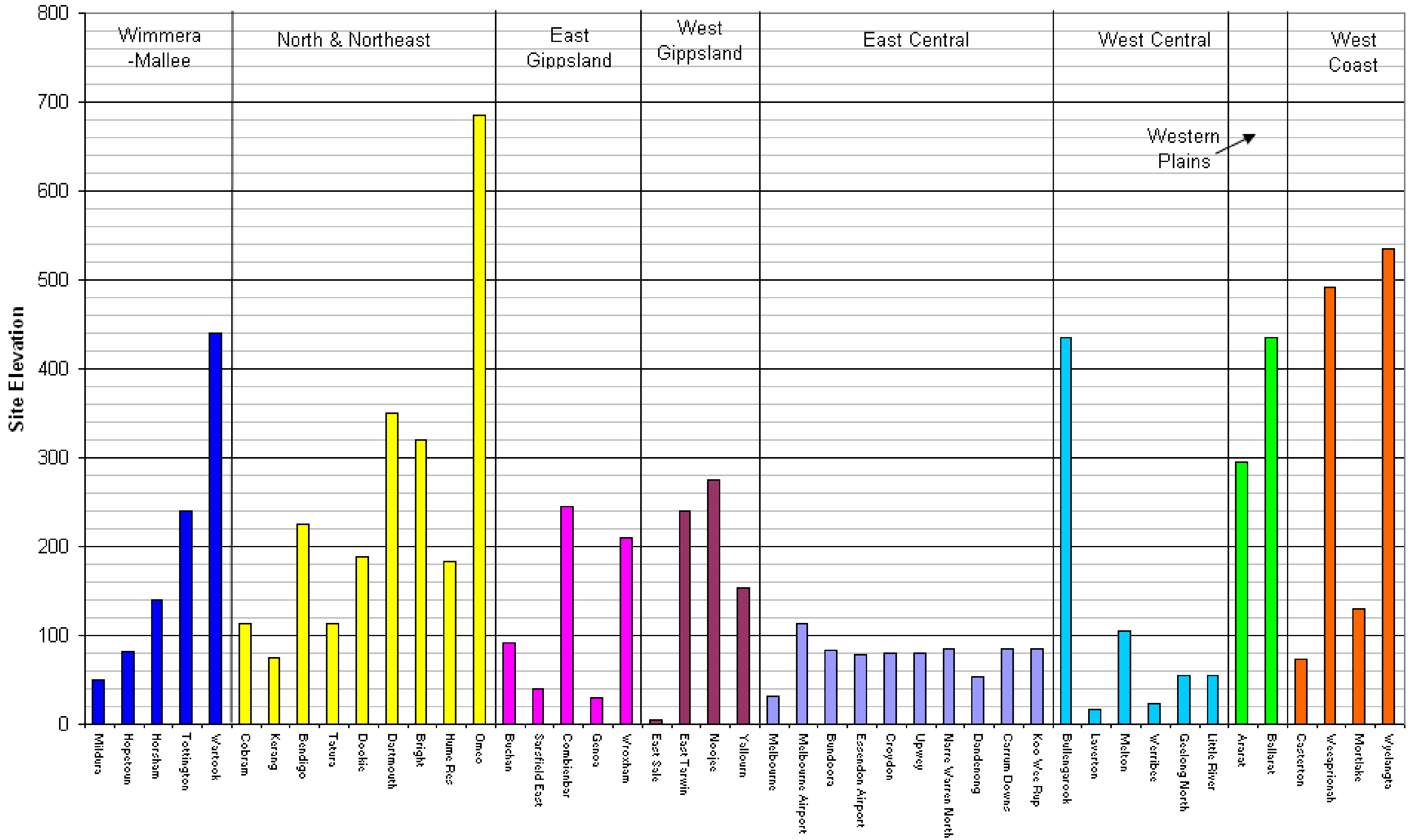

Figure B.3.6 Elevation at pluviographic station sites.

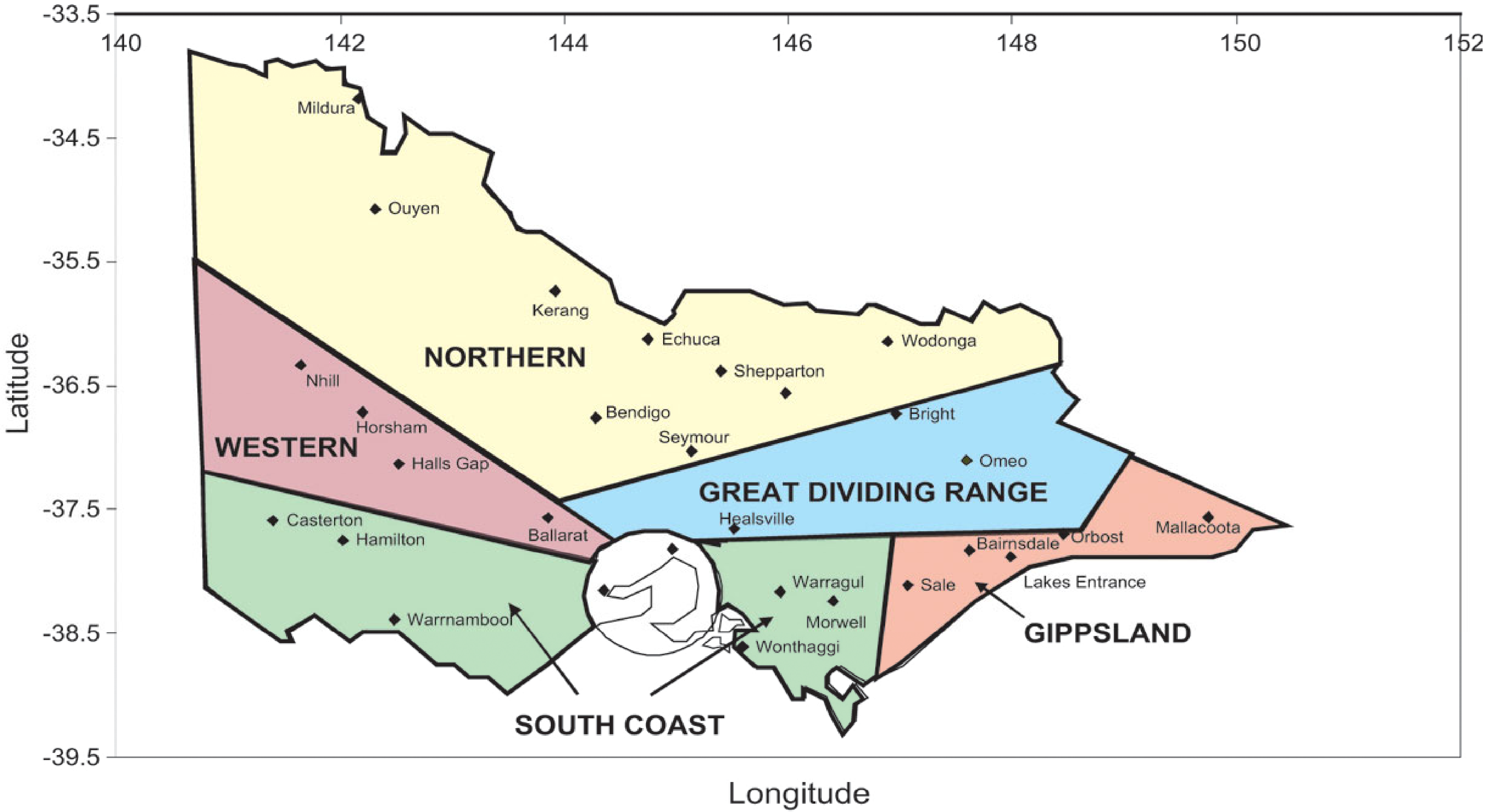

Figure B.3.7 Hydrologic regions for Greater Victoria (Melbourne and Geelong have been considered separately).

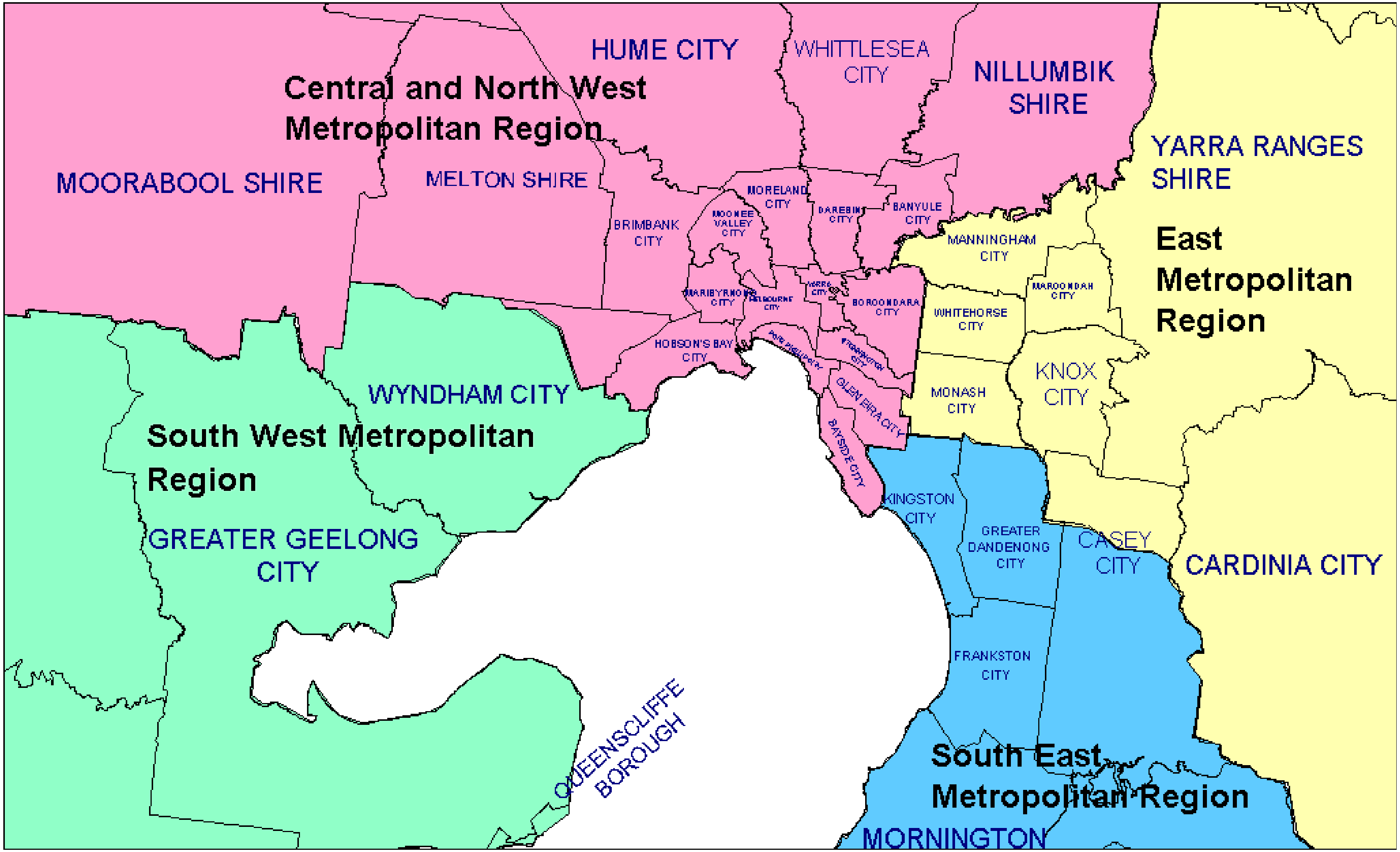

Figure B.3.8 Hydrologic regions for the Melbourne/Geelong Metropolitan area.

B.4 Hydrologic region adjustment factors

B.4.1 Adjustment factors for Greater Victoria

B.4.1.1 Wetlands

Figure B.4.1 shows a plot of the adjustment factors derived against MAR for the 30 stations in Greater Victoria grouped into five hydrologic regions. A trend of increasing adjustment factor with MAR is evident for each of the five regions.

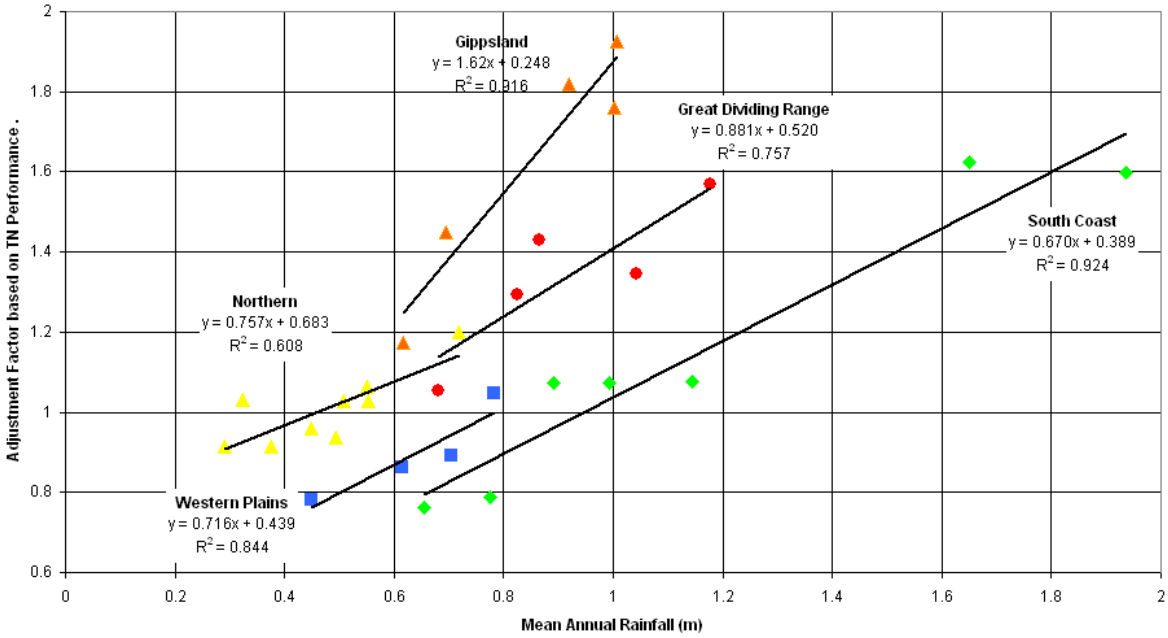

Figure B.4.1 Plot of adjustment factors versus Mean Annual Rainfall (MAR) for wetlands in Greater Victoria.

Equations to compute adjustment factors for each region were obtained by plotting a linear trend (i.e. 'line of best fit') for the points on Figure B.4.1 for each hydrologic region. The wetland adjustment factor equations are shown in Table B.4.1.

Table B.4.1 Wetland adjustment factor equations

Region	Wetland size adjustment factor equation
Northern	Adjustment factor = 0.757(MAR) + 0.683 [R2 = 0.61]
Western Plains	Adjustment factor = 0.716(MAR) + 0.439 [R2 = 0.84]
South Coast	Adjustment factor = 0.670(MAR) + 0.389 [R2 = 0.92]
Great Dividing Range	Adjustment factor = 0.881(MAR) + 0.520 [R2 = 0.76]
Gippsland	Adjustment factor = 1.62(MAR) + 0.248 [R2 = 0.76]

Figure B.4.2 shows a plot of the observed adjustment factor for each station (i.e. determined from the MUSIC modelling) and the predicted adjustment factor (i.e. obtained from the empirical equation determined for each hydrologic region). The dotted lines mark a 10% difference between the predicted and observed adjustment factor. All the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

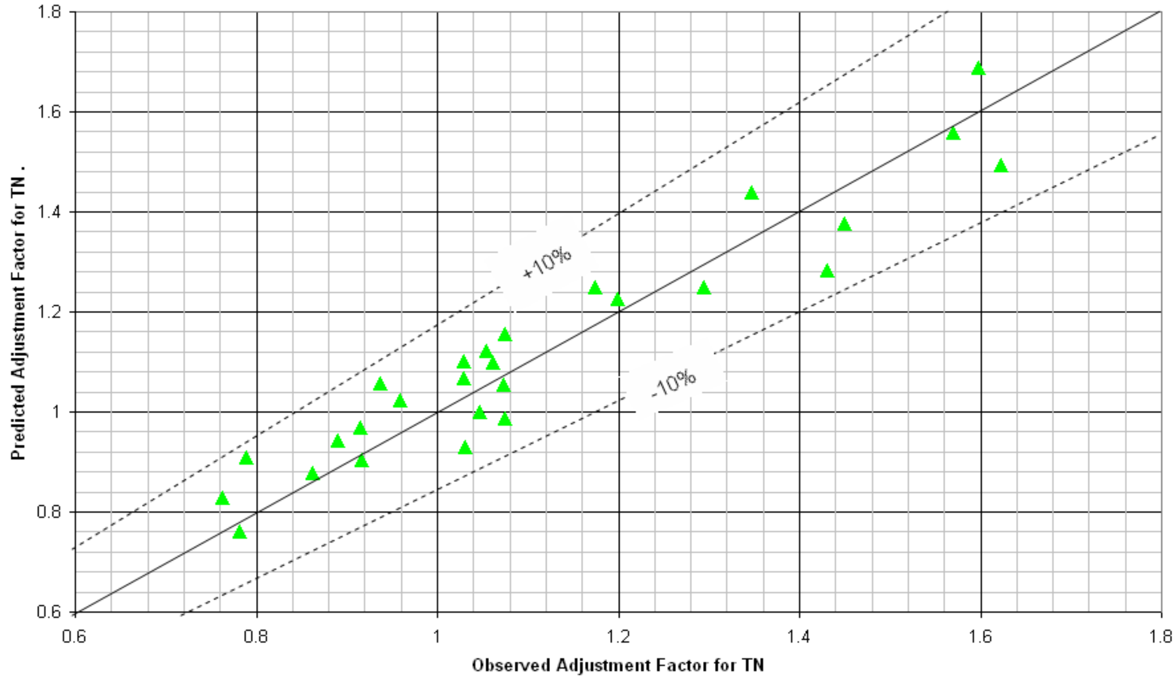

Figure B.4.2 Predicted versus observed adjustment factors for wetlands in Greater Victoria.

B.4.1.2 Bioretention systems

Figure B.4.3 shows a plot of the adjustment factors derived for the 30 stations and the corresponding MAR. Again, a trend of increasing adjustment factor with MAR is evident for each of the hydrologic regions.

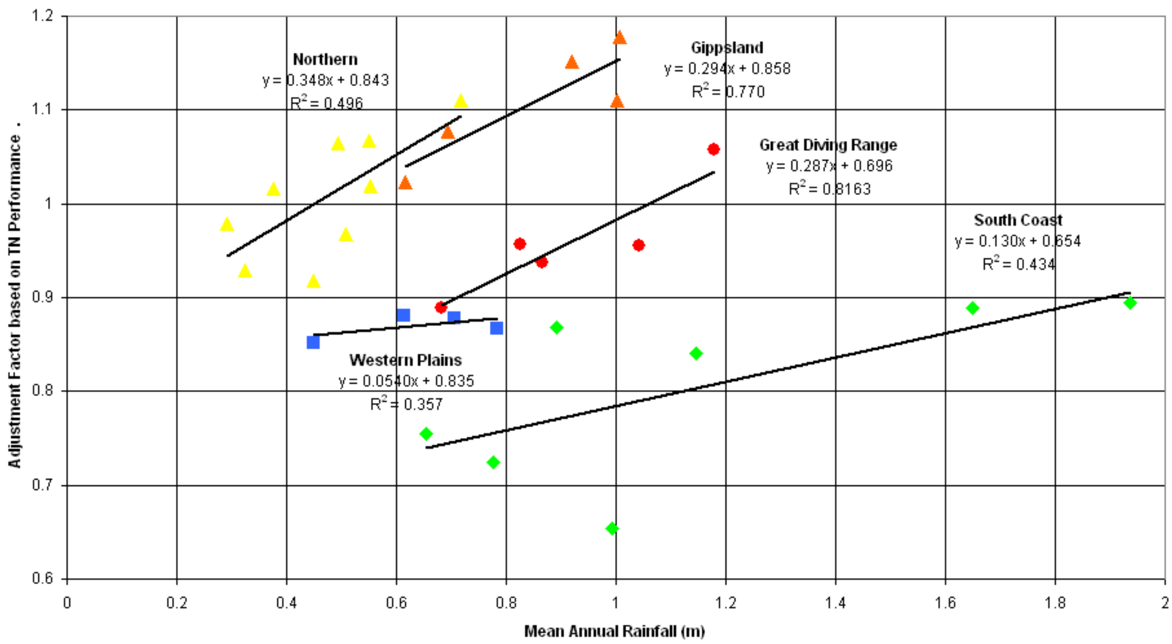

Figure B.4.3 Plot of bioretention system adjustment factor versus Mean Annual Rainfall (MAR) for bioretention systems in Greater Victoria.

The bioretention system size adjustment factor equations are shown in Table B.4.2.

Table B.4.2 Bioretention system size adjustment factor equations

Region	Bioretention system size adjustment factor equation
Northern	Adjustment factor = 0.348(MAR) + 0.843 [R2 = 0.50]
Western Plains	Adjustment factor = 0.054(MAR) + 0.835 [R2 = 0.36]
South Coast	Adjustment factor = 0.130(MAR) + 0.654 [R2 = 0.43]
Great Dividing Range	Adjustment factor = 0.287(MAR) + 0.696 [R2 = 0.82]
Gippsland	Adjustment factor = 0.294(MAR) + 0.858 [R2 = 0.77]

Figure B.4.4 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. All but two of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors. Predictions for two stations lie outside 10% of the observed values. They are Yallourn (16% difference) and East Tarwin (11% difference), both in the South Coast region.

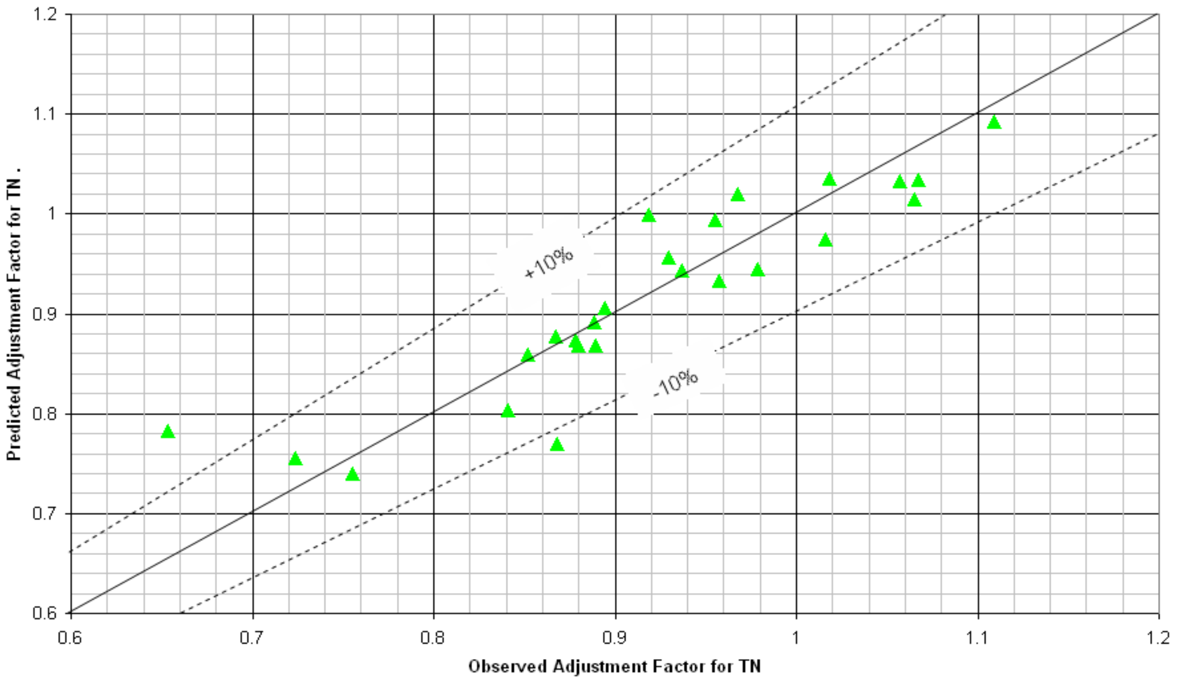

Figure B.4.4 Predicted versus 'observed' adjustment factors for bioretention systems in Greater Victoria.

B.4.2.3 Swales

Figure B.4.5 shows a relationship between the adjustment factors derived and MAR for the 30 stations grouped by their regions. Again, a trend of increasing adjustment factor with MAR is evident for each of the hydrologic regions.

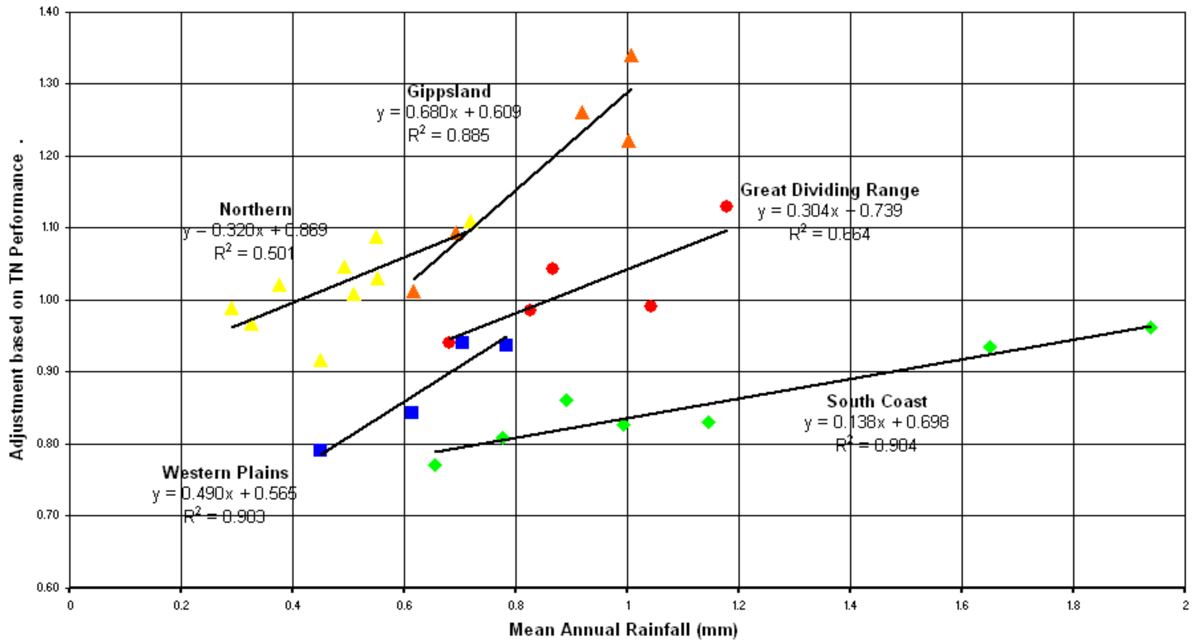

Figure B.4.5 Plot of adjustment factor versus Mean Annual Rainfall (MAR) for swales in Greater Victoria.

The swale size adjustment factor equations are shown in the Table B.4.3

Table B.4.3 Swale size adjustment factor equations

Region	Swale size adjustment factor equation
Northern	Adjustment factor = 0.320(MAR) + 0.869 [R2 = 0.50]
Western Plains	Adjustment factor = 0.490 (MAR) + 0.565 [R2 = 0.90]
South Coast	Adjustment factor = 0.138(MAR) + 0.698 [R2 = 0.90]
Great Dividing Range	Adjustment factor = 0.304(MAR) + 0.739 [R2 = 0.64]
Gippsland	Adjustment factor = 0.680(MAR) + 0.609 [R2 = 0.89]

Figure B.4.6 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. All the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

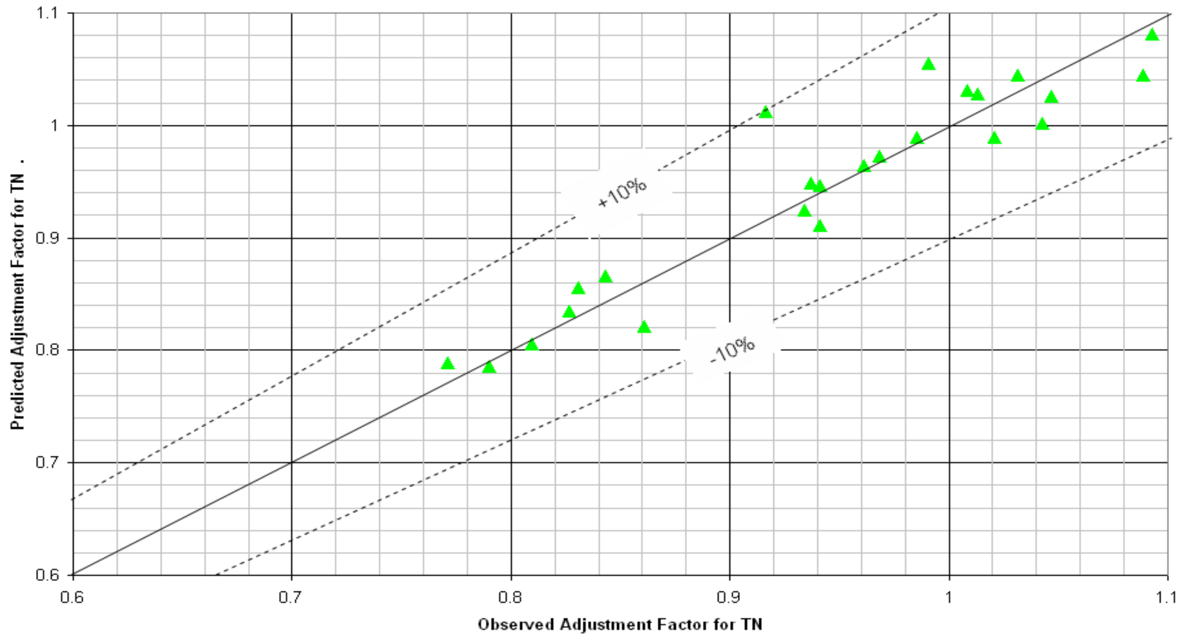

Figure B.4.6 Predicted versus 'observed' adjustment factors for swales in Greater Victoria.

B.4.1.4 Ponds

Figure B.4.7 shows a plot of the relationship between the adjustment factors derived and the MAR for the 30 stations grouped by their regions. Again, a trend of increasing adjustment factor with MAR is evident for each of the hydrologic regions.

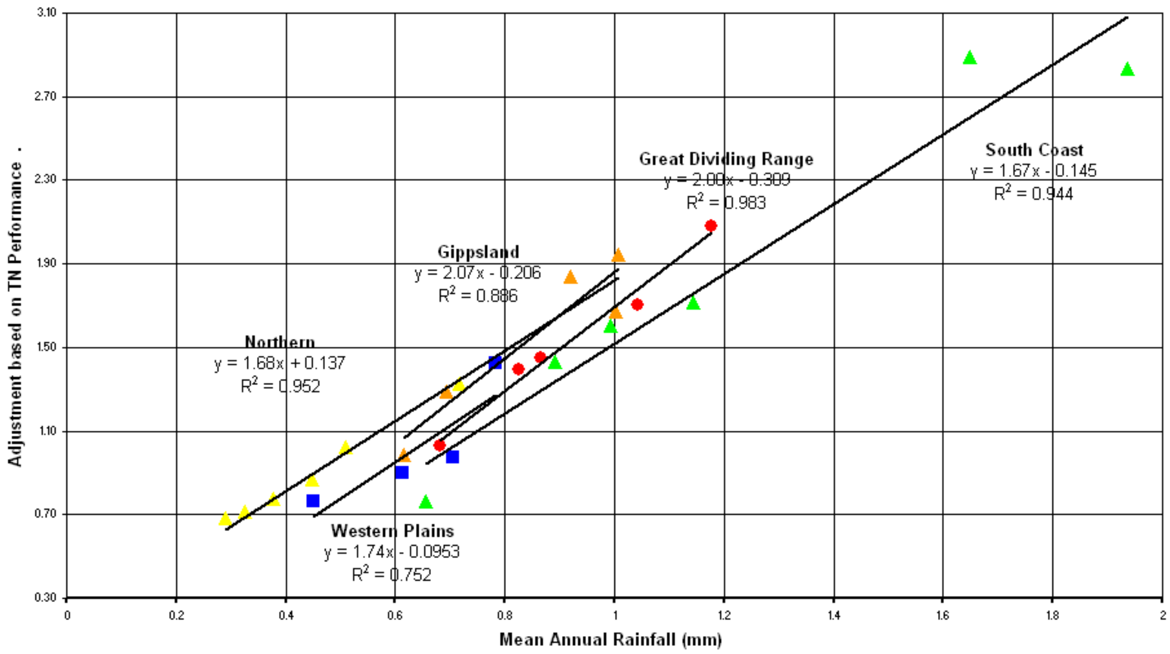

Figure B.4.7 Plot of adjustment factor versus Mean Annual Rainfall (MAR) for ponds in Greater Victoria.

There appears to be a stronger correlation between the size adjustment factor and MAR for ponds than for other treatment measures.

The pond size adjustment factor equations are shown in Table B.4.4.

Table B.4.4 Pond size adjustment factor equations

Region	Pond size adjustment factor equation
Northern	Adjustment factor = 1.68(MAR) + 0.137 [R2 = 0.95]
Western Plains	Adjustment factor = 1.74(MAR) – 0.0953 [R2 = 0.75]
South Coast	Adjustment factor = 1.67(MAR) – 0.145 [R2 = 0.94]
Great Dividing Range	Adjustment factor = 2.00(MAR) – 0.309 [R2 = 0.98]
Gippsland	Adjustment factor = 2.07(MAR) – 0.206 [R2 = 0.89]

Figure B.4.8 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. All but two of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors. Predictions for the two stations that lie outside 10% of the observed values are Casteron (19% difference) in the South Coast region and Ballarat (14% difference) in the Western Region.

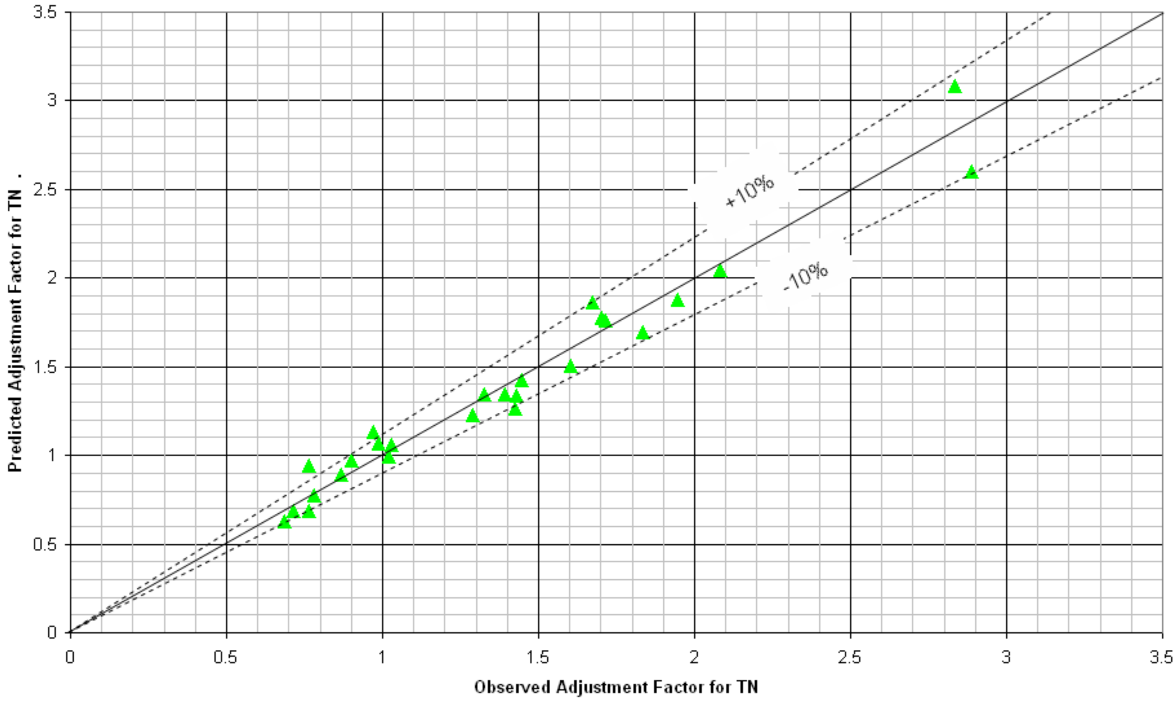

Figure B.4.8 Predicted versus ‘observed’ adjustment factors for ponds in Greater Victoria.

B.4.2 Adjustment factors for the Melbourne/Geelong metropolitan region

B.4.2.1 Wetlands

Figure B.4.9 shows a plot of the wetland size adjustment factor*s* derived against MAR for the 15 stations in the Melbourne/Geelong metropolitan region and grouped into four regions. For the central and north-west region, there appears to be a negative correlation between the adjustment factor and MAR. For the other three regions, the adjustment factor can best be represented by a single value for the region. Rainfall at stations to the east of Melbourne is consistently higher that at stations to the west of Melbourne but this does not necessarily lead to larger required treatment area for wetlands in the eastern metropolitan areas. Seasonal rainfall patterns which are implicitly accounted for in the regionalisation procedure compensate for the influence of MAR in this case. The eastern region of metropolitan Melbourne has a more evenly distributed rainfall over the year compared with the western metropolitan region.

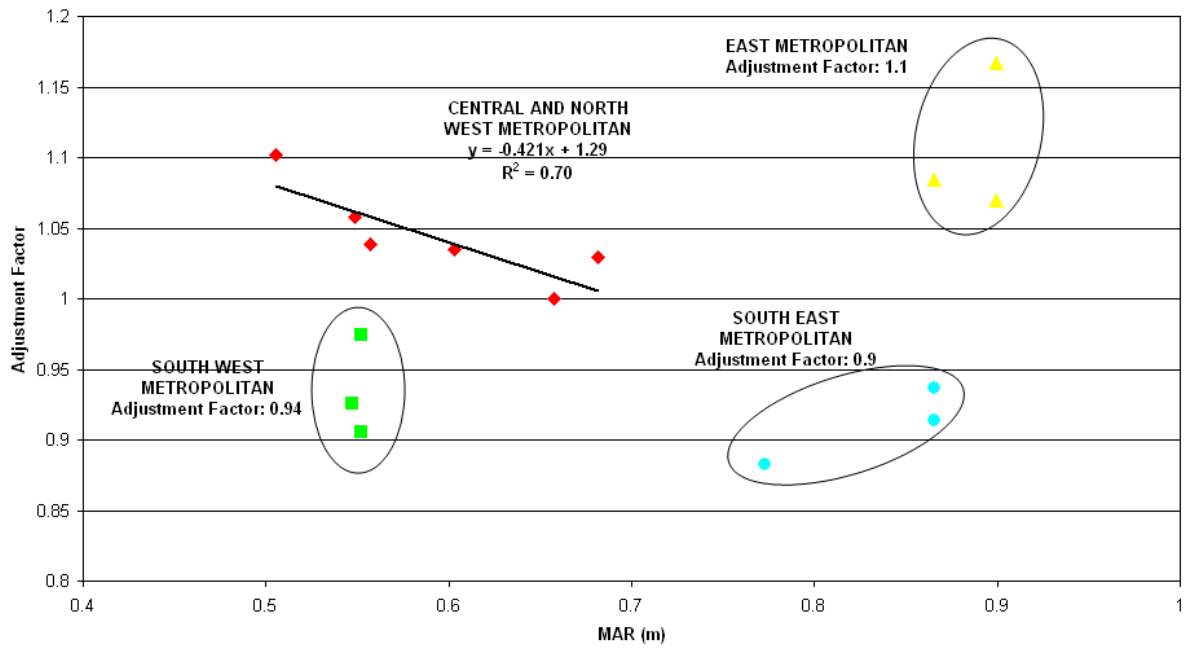

Figure B.4.9 Adjustment factor versus Mean Annual Rainfall (MAR) for wetlands in the Melbourne/Geelong metropolitan region.

The equation to compute the adjustment factor for the central and north-west metropolitan region was obtained by plotting a linear trend (i.e. line of best fit) through the points for this region. This equation and the adjustment factor for the other three regions are shown in Table B.4.5.

Table B.4.5 Wetland adjustment factor equations

Region	Wetland adjustment factor equation
Central and North West Metropolitan	Adjustment factor = -0.421(MAR) + 1.29 [R2 = 0.70]
South West Metropolitan	Adjustment factor = 0.94
East Metropolitan	Adjustment factor = 1.1
South East Metropolitan	Adjustment factor = 0.9

Figure B.4.10 shows a plot of the observed adjustment factor for each station (i.e. determined from the MUSIC model) and the predicted adjustment factor (i.e. that obtained from the equations/values in Table B.4.5. The dotted lines mark a 10% difference between the predicted and observed adjustment factor. All of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

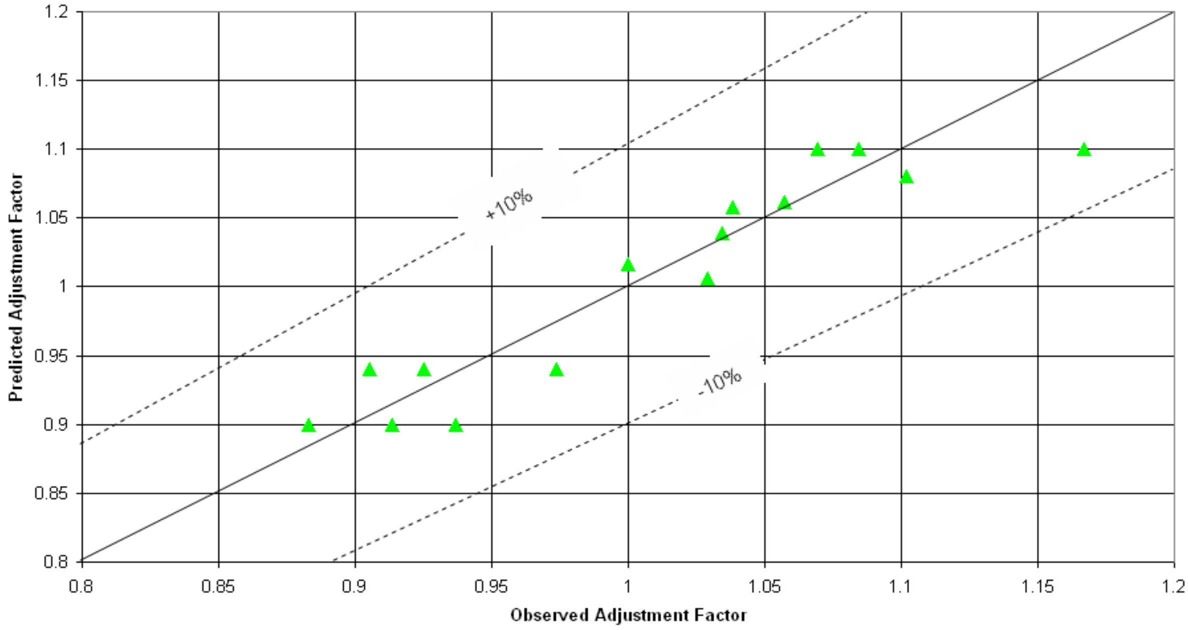

Figure B.4.10 Predicted versus 'observed' adjustment factors for wetlands in the Melbourne/Geelong metropolitan region.

B.4.2.2 Bioretention systems

Figure B.4.11 shows a plot of the bioretention system size adjustment factor*s* derived for the 15 stations in the Melbourne/Geelong metropolitan region and the corresponding MAR. For the central and north-west region, there appears to be a negative correlation between the adjustment factor and MAR. For the other three regions, the adjustment factor can best be represented by a single value for the region.

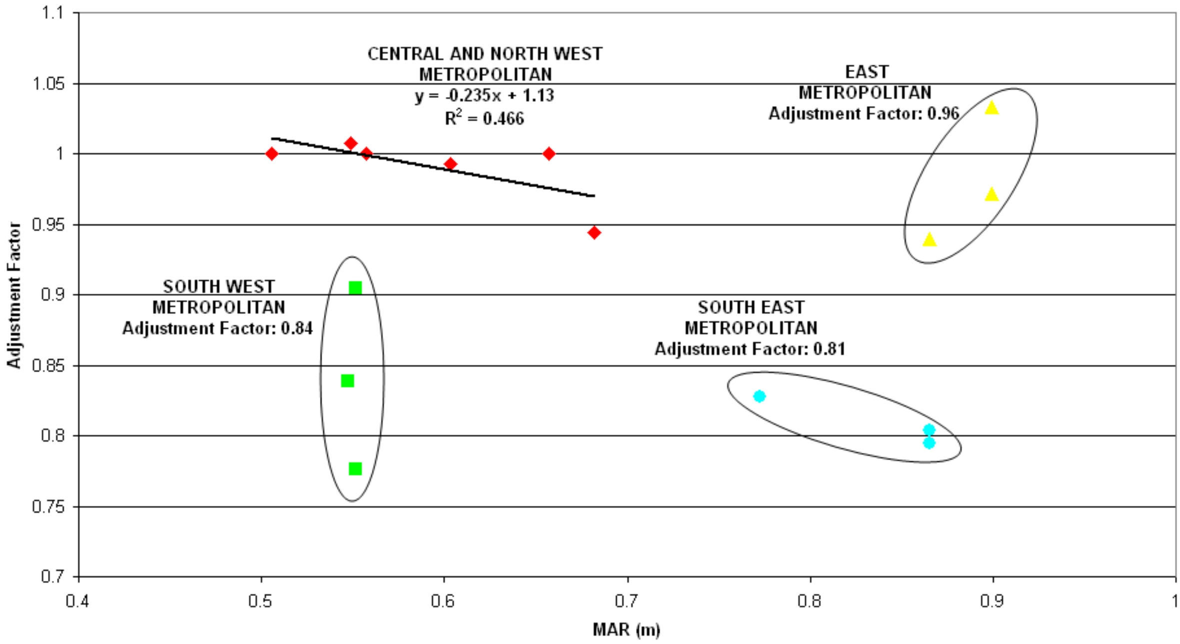

Figure B.4.11 Adjustment factor versus Mean Annual Rainfall (MAR) for bioretention systems in the Melbourne/Geelong metropolitan region.

An equation to compute the adjustment factor for the central and north-west metropolitan region and the adjustment factor for the other three regions are shown in Table B.4.6.

Table B.4.6 Bioretention system size adjustment factor equations

Region	Bioretention system size adjustment factor equation
Central and North West Metropolitan	Adjustment factor = -0.235(MAR) + 1.13 [R2 = 0.47]
South West Metropolitan	Adjustment factor = 0.84
East Metropolitan	Adjustment factor = 0.96
South East Metropolitan	Adjustment factor = 0.81

Figure B.4.12 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. It can be seen that all of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

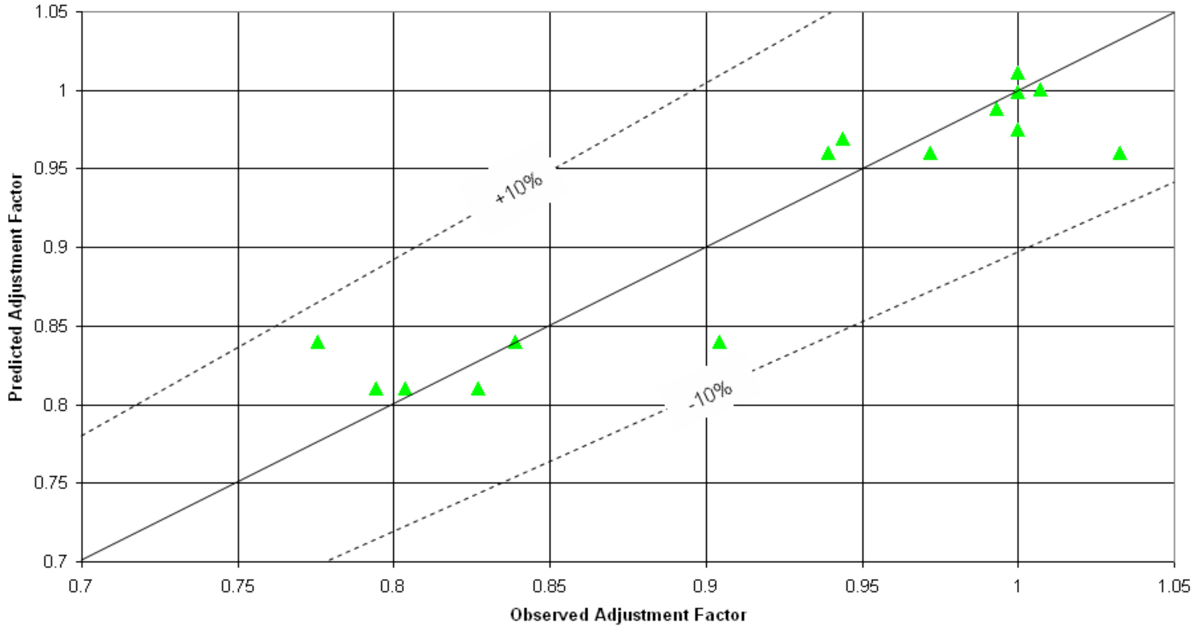

Figure B.4.12 Predicted versus observed adjustment factors for bioretention systems in the Melbourne/Geelong metropolitan region.

B.4.2.3 Swales

Figure B.4.13 shows a plot of the swale size adjustment factors derived for the 15 stations in the Melbourne/Geelong metropolitan region and the corresponding MAR. For the central and north-west metropolitan region, there appears to be a negative correlation between the adjustment factor and MAR. For the other three regions, the adjustment factor can best be represented by a single value for the region.

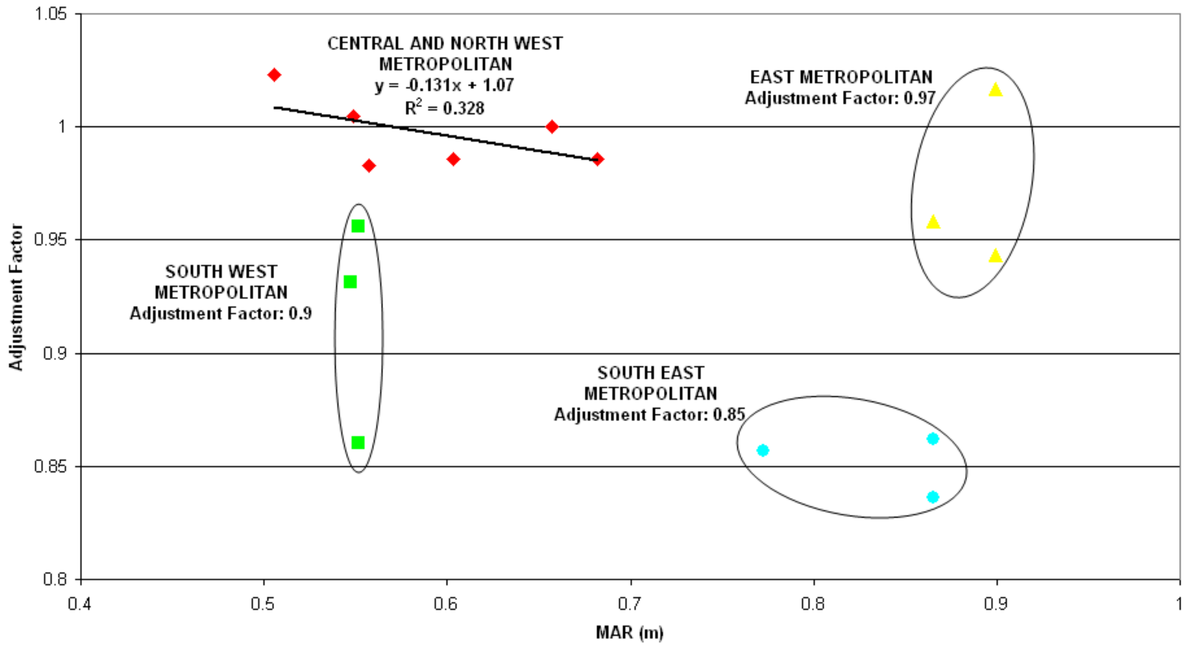

Figure B.4.13 Adjustment factor versus Mean Annual Rainfall (MAR) for swales in the Melbourne/Geelong metropolitan region.

The equation to compute the adjustment factor for the central and north-west region and the adjustment factor for the other three regions are shown in Table B.4.7.

Table B.4.7 Swale size adjustment factor equations

Region	Swale size adjustment factor equation
Central and North West Metropolitan	Adjustment factor = -0.131(MAR) + 1.07 [R2 = 0.33]
South West Metropolitan	Adjustment factor = 0.9
East Metropolitan	Adjustment factor = 0.97
South East Metropolitan	Adjustment factor = 0.85

FigureB.4.14 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. All of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

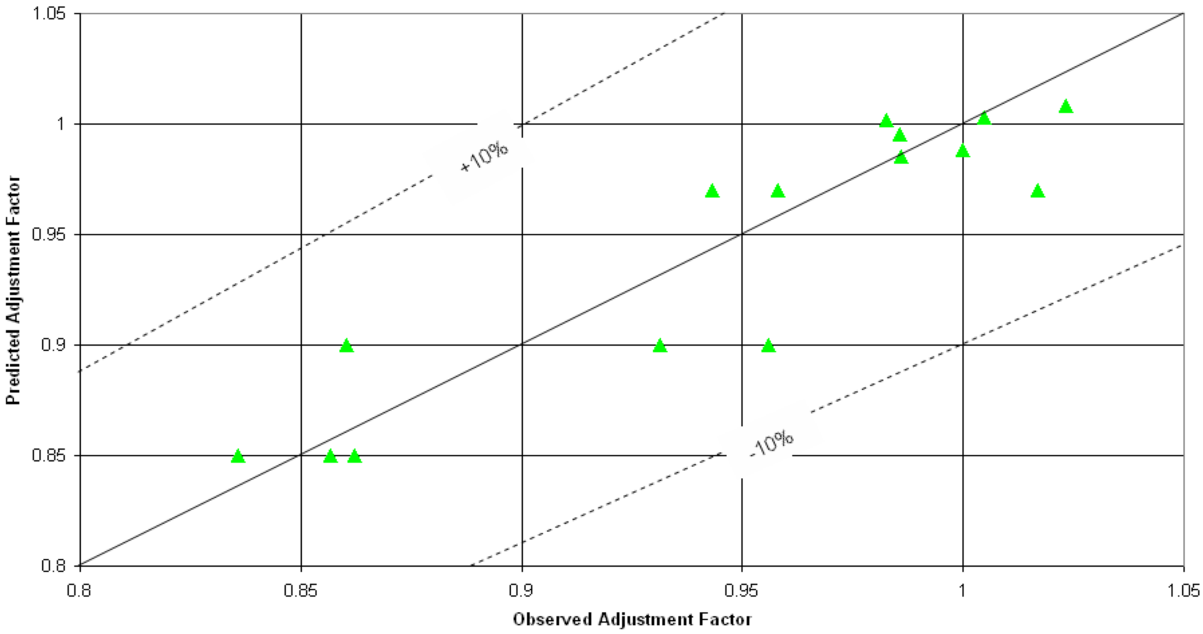

Figure B.4.14 Predicted versus observed adjustment factors for swales in the Melbourne/Geelong metropolitan region.

B.4.2.4 Ponds

Figure B.4.15 shows a plot of the pond size adjustment factors derived for the 15 stations in the Melbourne/Geelong metropolitan region and the corresponding MAR. For the central and north-west metropolitan region, there appears to be a positive correlation between the adjustment factor and MAR. For the other three regions, the adjustment factor can best be represented by a single value for the region.

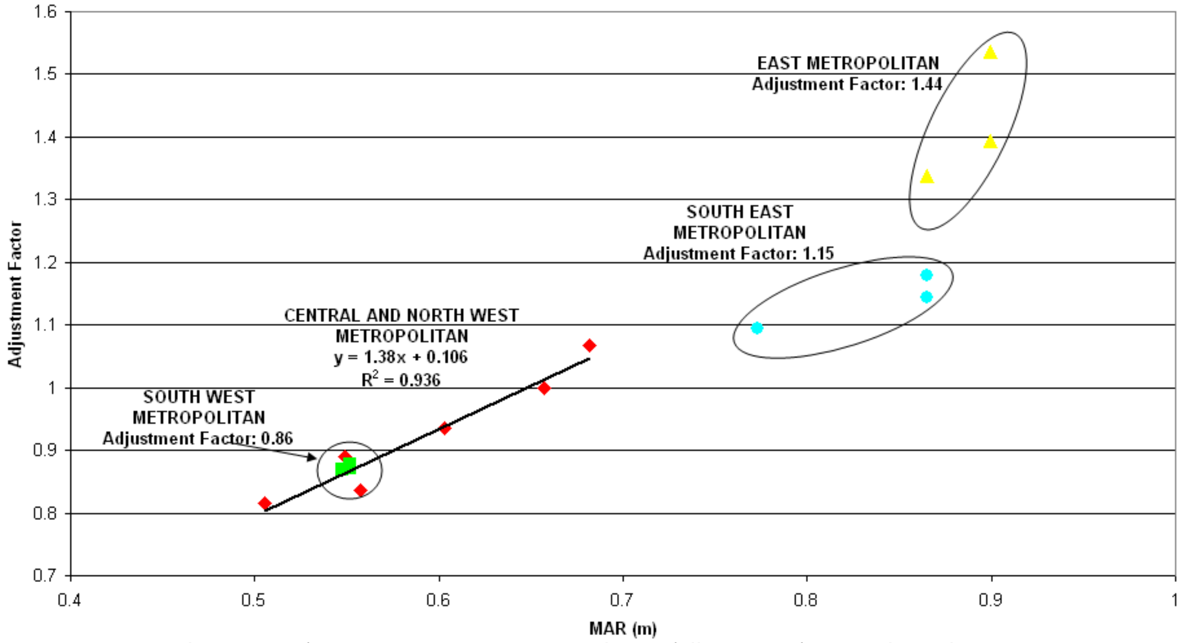

Figure B.4.15 Adjustment factor versus Mean Annual Rainfall (MAR) for ponds in the Melbourne/Geelong metropolitan region.

The impact of MAR appears to be greater for ponds than for the other three treatment measures. The sites to the east of Melbourne with higher MARs have higher adjustment factors than those on the western side.

The equation to compute the adjustment factor for the central and north-west metropolitan region and the adjustment factor for the other three regions are shown in Table B.4.8.

Table B.4.8 Pond adjustment factor equations

Region	Pond adjustment factor equation
Central and North West Metropolitan	Adjustment factor = 1.38(MAR) + 0.106 [R2 = 0.94]
South West Metropolitan	Adjustment factor = 0.86
East Metropolitan	Adjustment factor = 1.44
South East Metropolitan	Adjustment factor = 1.15

Figure B.4.16 shows a plot of the observed adjustment factor for each station and the predicted adjustment factor. All of the predicted adjustment factors are within 10% of the corresponding observed adjustment factors.

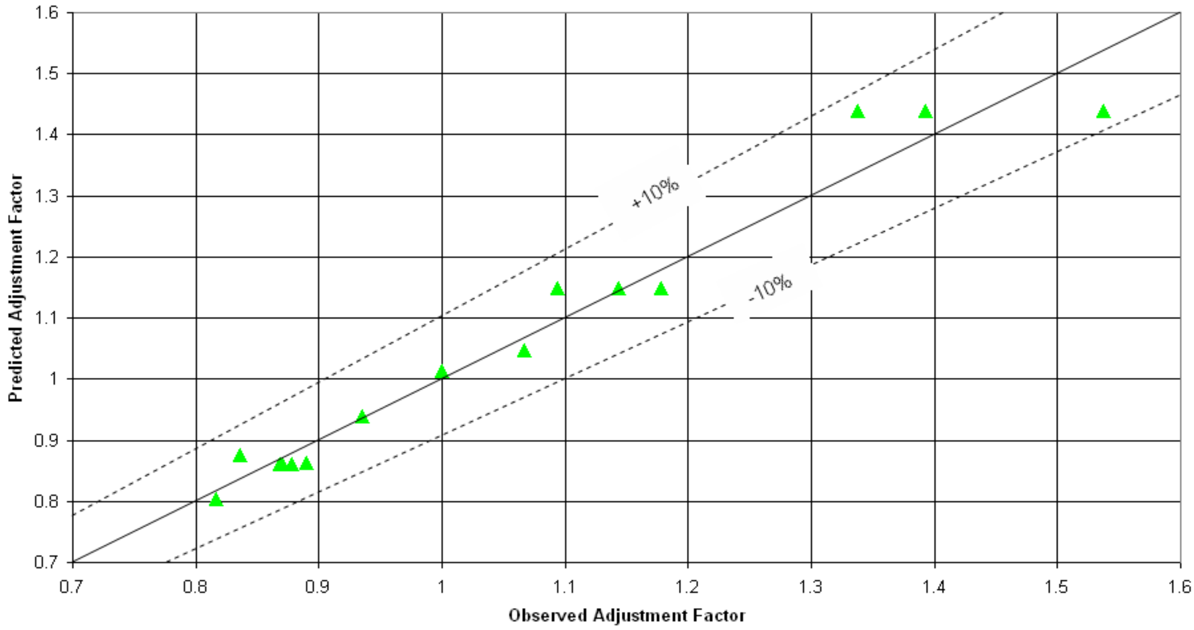

Figure B.4.16 Predicted versus observed adjustment factors for ponds in the Melbourne/Geelong metropolitan region.

B.5 Adjustment factors for reference rainfall stations

The regional equations and constants for computing adjustments factors are the result of pooling modelling results for relevant reference pluviographic stations within each hydrologic region. To ensure a systematic application of the procedure, it is recommended that computation of adjustment factor*s* should exclusively use the regional equations or constants provided instead of individually derived values for adjustment factors, irrespective of the proximity of the site to a reference pluviographic station. This would avoid situations where practitioners get to choose between the adjustment factor computed from the regional approach and that derived for the reference pluviographic station of close proximity to the site in question.

If the option for practitioners to use adjustment factor*s* derived for individual reference pluviographic stations is to be provided, a consistent approach to define the areal extent of applicability of adjustment factors derived for individual pluviographic stations will need to be developed. This areal extent of applicability for individual reference pluviographic station may vary depending on its proximity to other pluviographic stations and will probably be determined in an ad hoc manner. Furthermore, this option could also introduce debate among practitioners about the selection of reference pluviographic stations for the present analysis ahead of others which may be of 'more relevant' to their particular sites.

It is recommended that only regional relationships for adjustment factors be used in this document.

B.6 Recommended adjustment factors

The plots comparing the predicted adjustment factors to those determined from MUSIC modelling indicate that the regional equations and constants derived for the five state-wide hydrologic regions and four regions for the Melbourne/Geelong metropolitan region fall within a 10% band. It is, thus, reasonable to adopt an adjustment factor that is 1.1 times (i.e. within 10%) the amount predicted by these equations and constants to ensure that predicted size of stormwater treatment measures using this method will not be an underestimation of what is required. This preserves the opportunity (and incentive) for practitioners to adopt a more rigorous approach (e.g. MUSIC modelling using local rainfall data) to further refine and reduce the size of treatment measures being considered if they so desire. The recommended equations and constants (including a + 10% adjustment) for computing the appropriate adjustment factors for Victoria, including the Melbourne/Geelong metropolitan region, are summarised in Tables B.6.1 and B.6.2.

Table B.6.1 Greater Victoria adjustment factors

Region	Wetland	Bioretention	Swale	Pond
Northern	0.833(MAR) + 0.751	0.383(MAR) + 0.927	0.352(MAR) + 0.956	1.85(MAR) + 0.151
Western Plains	0.788(MAR) + 0.483	0.059(MAR) + 0.919	0.539(MAR) + 0.622	1.91(MAR) – 0.105
South Coast	0.737(MAR) + 0.428	0.143(MAR) + 0.719	0.152(MAR) + 0.768	1.84(MAR) – 0.160
Great Dividing Range	0.969(MAR) + 0.572	0.316(MAR) + 0.766	0.334(MAR) + 0.813	2.20(MAR) – 0.340
Gippsland	1.78(MAR) + 0.273	0.325(MAR) + 0.944	0.748(MAR) + 0.670	2.28(MAR) – 0.227

Table B.6.2 Melbourne/Geelong metropolitan region adjustment factors

Region	Wetland	Bioretention	Swale	Pond
Central and North West Metropolitan	– 0.463(MAR) + 1.421	– 0.259(MAR) + 1.243	– 0.144(MAR) + 1.18	1.52(MAR) + 0.117
South West Metropolitan	1.03	0.924	0.99	0.946
East Metropolitan	1.21	1.06	1.07	1.58
South-east Metropolitan	0.99	0.891	0.935	1.27

B.7 Example of an application of a Mean Annual Rainfall method

Figure B.7.1 is a plot of the wetland performance of constructed stormwater treatment wetlands based on a series of MUSIC simulations using Melbourne rainfall. This is the reference plot for the sizing of constructed wetlands (with 0.75 extended detention and 72-hour notional detention time) in Victoria.

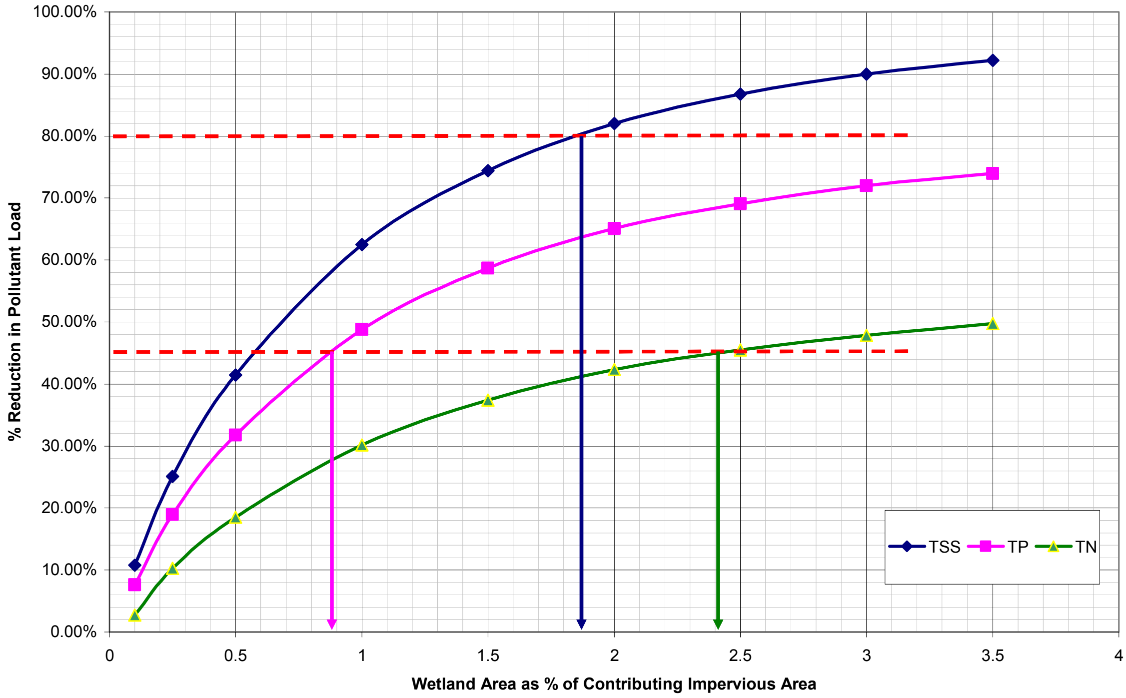

Figure B.7.1 Performance curve for constructed wetlands in Melbourne.

To satisfy the objectives for the performance of stormwater treatment of 80% reduction in TSS and 45% reduction in TP and TN in Melbourne, the required wetland size is to be about 2.4% of the contributing impervious area in the catchment. The required wetland size for reduction of TN was the critical design condition in this case [i.e. a larger wetland is needed to meet the TN objectives than the TSS (1.86% impervious area) and TP (0.88% impervious area)] objectives. The area will then need to be adjusted with the wetland size adjustment factor derived from Table B.6.2.

For example, the required wetland area for a development in Gippsland with MAR of 850 mm, a catchment area of 50 ha and a fraction impervious area of 0.5 is computed as follows.

1. From Figure B.7.1, the reference wetland area is 2.4% of the contributing impervious area,

   i.e. contributing impervious area = $0.5 \times 500\,000 = 250\,000$ m^2

   reference wetland area = $0.024 \times 250\,000 = 6000$ m^2.

2. The adjustment factor for Gippsland region is computed using the equation in Table B.6.1:

   adjustment factor = 1.78(MAR) + 0.273

   = 1.78(0.85) + 0.273 = 1.8

3. The required wetland area is $1.8 \times 6000 =$ **10 800** m^2.

B.8 Summary

A simple procedure for sizing stormwater treatment measures to meet current best practice environmental management objectives for stormwater is proposed here. This procedure is based on defining nine hydrologic regions within Victoria (four or which are in the Melbourne/Geelong metropolitan area). Empirical methods for determining an adjustment factor for sites within these regions have been derived for the design of constructed wetlands, bioretention systems, swales and ponds.

Melbourne was selected as the reference site in this procedure. Detailed simulations of a wide range of treatment measures with different configurations for this reference site will now be undertaken to provide a comprehensive set of performance curves. These curves can then be adapted for use in different sites across Victoria by use of adjustment factors. The relevant value of an adjustment factor for any particular site can be computed from the relevant equations for the hydrologic region and this is then used to adjust the area of the treatment measure found suitable for Melbourne.

B.9 References

Cooperative Research Centre for Catchment Hydrology (CRCCH) (2003). *Model for Urban Stormwater Improvement Conceptualisation (MUSIC) User Guide*, Version 2.0, December, CRCCH, Monash University, Victoria.