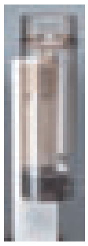
Chapter 2 Hydrologic design regions of Victoria

2.1 Introduction

This chapter describes the development and use and of a simple design procedure for sizing **stormwater** treatment facilities across Victoria for small development projects (e.g. single or small clustered allotments). The procedure does not require any modelling. In addition, the procedure can be used as a simple tool to assess whether a proposed design is of sufficient size. The procedure is based on adjusting the size of the treatment measure from a reference site (Melbourne) to other parts of Victoria to achieve similar levels of pollutant removal.

To determine the **adjustment factors** a set of equations that only requires local Mean Annual Rainfall (MAR) data has been developed. This approach is based on defining nine **hydrologic design regions** within Victoria (four or which are in the Melbourne/Geelong metropolitan area) with adjustment factors for **wetlands**, **swales**, **ponds** and bioretention systems.

Melbourne was selected as the reference site. Estimated pollutant reductions from simulations for a range of treatment measures with different configurations for this reference site are presented in later chapters (see Chapters 4–10). These curves can then be adapted using the adjustment factors for use in different sites across Victoria. A required treatment area (i.e. the size of the facility) derived for the reference site (Melbourne) can be converted into an equivalent treatment area that will achieve the same level of treatment elsewhere in Victoria.

The results of this analysis are presented in this Chapter, while more details of the modelling approach and the model output are provided in Appendix B.

2.2 Approach to regionalisation

We have used a continuous simulation approach to help properly consider the influence of **antecedent conditions** on the design of stormwater treatment measures and the wide range of storm characteristics and hydraulic conditions that are relevant to individual treatments. Computer models such as the **Model for Urban Stormwater Improvement Conceptualisation (MUSIC)** (Cooperative Research Centre for Catchment Hydrology 2003), 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.

The following approach was used to develop the hydrologic regions and adjustment factors presented in this chapter and Appendix B.

1 A measure of effectiveness was selected for different configurations of various stormwater treatment measures. In this case, the reduction in annual total nitrogen loads was adopted

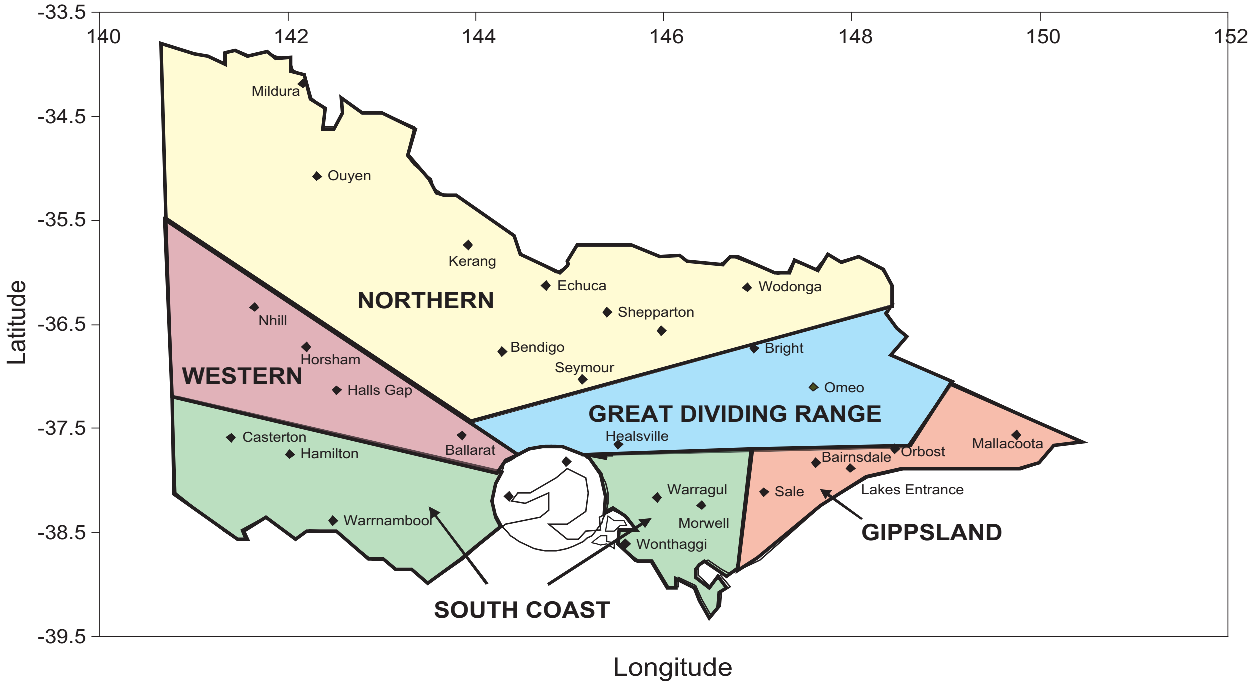


Figure 2.1 Hydrologic design regions for Greater Victoria (Melbourne and Geelong have been considered separately).

because it is commonly the limiting parameter in meeting the objectives for best practice stormwater quality.

2 A reference site was selected for which detailed performance curves were derived for different configurations (e.g. area, **extended detention** depth and **permanent pool** volume) of a range of stormwater treatment measures. Melbourne was selected as the reference site.

3 Hydrologic regions within Victoria were defined such that within each region the adjustment factor relationship was consistent. A simple equation for each region using MAR was developed that can be applied anywhere in the region.

Several geographical and meteorological factors were investigated for their influence on adjustment factors. They were limited to data that are readily available from Bureau of Meteorology website (http://www.bom.gov.au) and included mean annual rainfall, a measure of seasonal distribution of rainfall and raindays, site elevation and geographical location.

2.3 Determining hydrologic design regions

The hydrologic regions for **Water Sensitive Urban Design** (WSUD) were determined by using sufficiently long (i.e. about 20 years) sets of six-minute rainfall data for continuous simulations of the performance of stormwater treatment measures. We used 45 stations across Victoria in the analysis, of which 15 are in the Melbourne/Geelong metropolitan region (see Appendix B).

The MUSIC model 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 (i.e. the reference site) 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 2.2).

Following extensive testing and analysis of the significance of possible influencing factors, it was determined that MAR was the most significant. By using MAR it was possible to represent Victoria with five hydrologic regions (excluding the Melbourne/Geelong metropolitan region) (Figure 2.1).

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 (Figure 2.2).

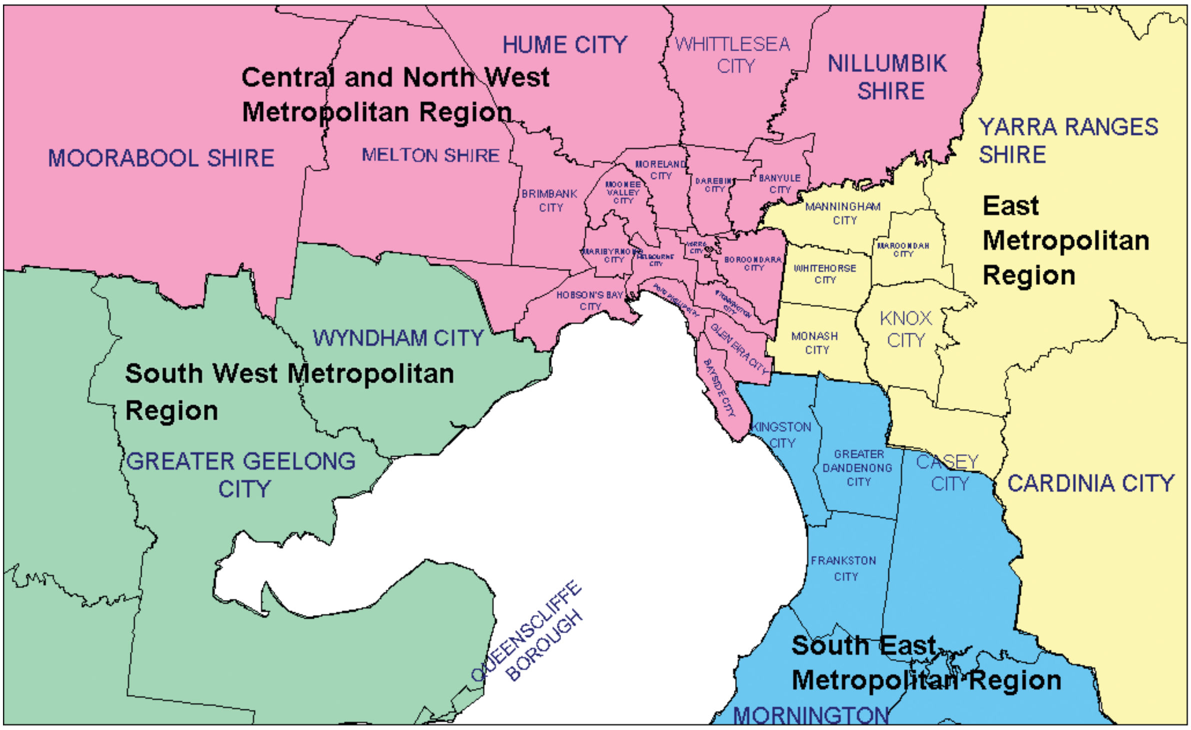


Figure 2.2 Hydrologic regions for the Melbourne/Geelong metropolitan area.

Boundaries of the hydrologic regions were determined to represent the results of the analysis. They were aligned so that they did not dissect major urban areas in Victoria or coincide 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 the Monash Freeway, respectively.

2.4 Hydrologic region adjustment factors

Figure 2.3 presents an example plot of adjustment factor equations (for wetlands) derived from 30 stations in Greater Victoria grouped into the five hydrologic regions. This was performed for each of the treatment measures (wetlands, swales, ponds and bioretention systems) using all 45 stations.

A line of best fit was determined for the adjustment factors plotted against MAR for each region (e.g. Figure 2.3). The adjustment factor equations were determined from these relationships.

Modelling results indicated that the regional equations derived for the five state-wide hydrologic regions and four regions for the Melbourne/Geelong metropolitan region fall within a ±10% band (see Appendix B). Thus, by adopting adjustment factors that are 1.1 times (i.e. +10%) that predicted by these equations, it is expected that the predicted size of stormwater treatment measures using this method will provide adequate sizes for the treatment performance required with a high degree of certainty (i.e. they may be slightly conservatively designed). This preserves the opportunity (and incentive) for designers to adopt a more rigorous approach if desired (e.g. MUSIC modelling using local rainfall data) to further refine and reduce the size of treatments.

In three of the four hydrologic regions shown in Figure 2.2, 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 Metropolitan and North West Metropolitan) represented as a function of MAR.

Inclusion of other factors such as raindays 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.

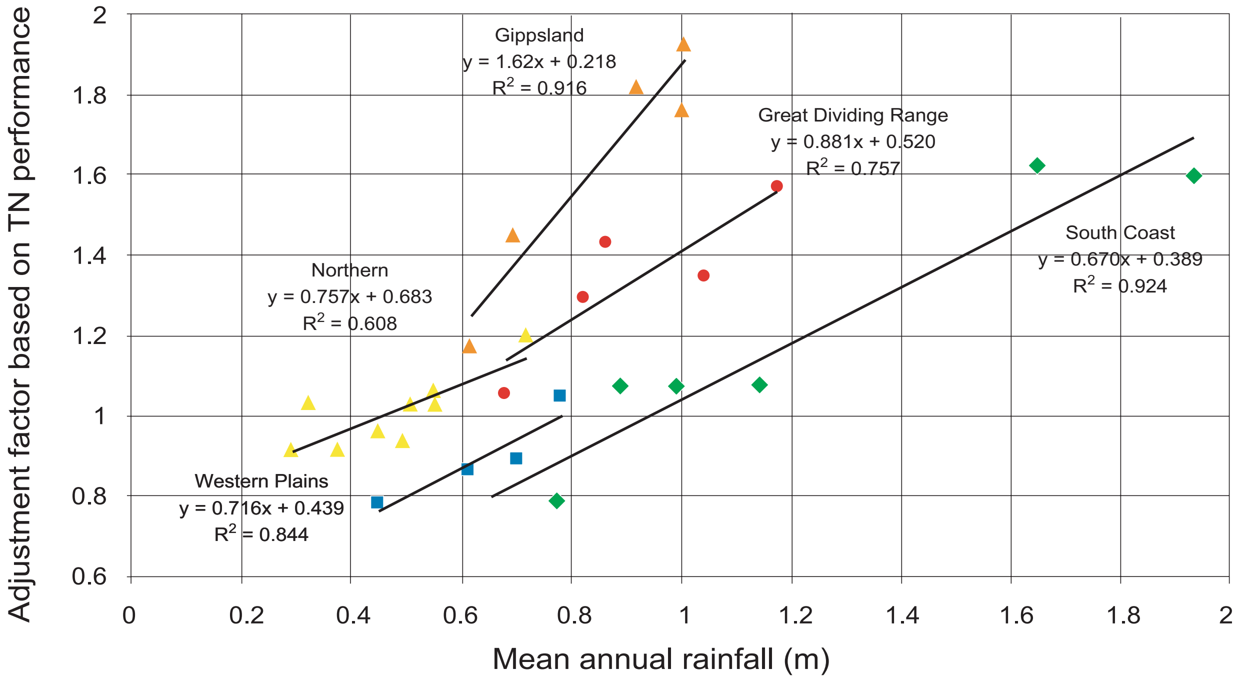


Figure 2.3 Plot of adjustment factor versus Mean Annual Rainfall (MAR) for wetlands in Greater Victoria.

The recommended equations and constants (including + 10% adjustment) for computing the appropriate adjustment factors for Victoria, including the Melbourne/Geelong metropolitan region, are summarised in Table 2.1 and Table 2.2.

Table 2.1 Greater Victoria adjustment factors
These figures are based on Figure 2.1

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	0.15 (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 2.2 Melbourne/Geelong metropolitan region adjustment factors
These figures are based on Figure 2.2

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	1.0	0.92	0.99	0.95
East Metropolitan	1.2	1.1	1.1	1.6
South East Metropolitan	0.99	0.89	0.94	1.3

2.5 Example application of mean annual rainfall method

Figure 2.4 shows a plot of treatment performance of a constructed stormwater wetland based on a series of MUSIC simulations using Melbourne rainfall. This is the reference plot for the sizing of **constructed wetlands** (with 0.75 m extended detention and 72 hour notional **detention time**) in Victoria.

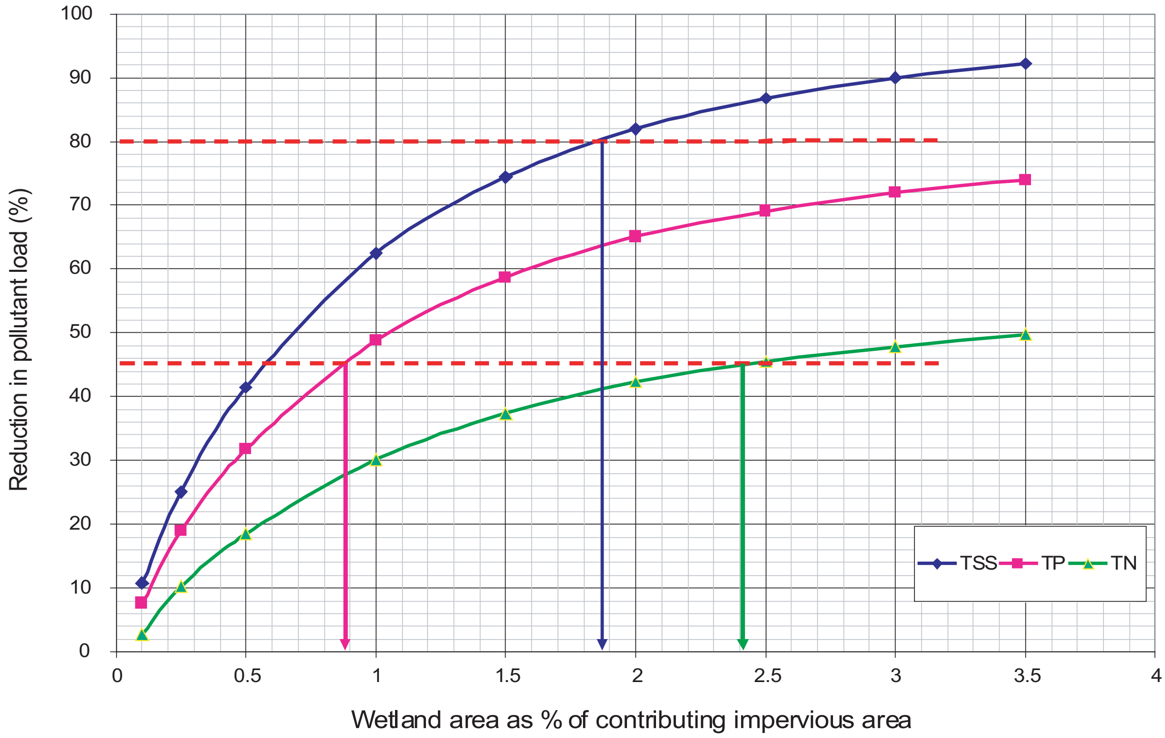


Figure 2.4 Performance curve for constructed wetlands in Melbourne.

To satisfy the objectives of stormwater treatment performance of 80% reduction in total soluble solids (TSS) and 45% reduction in total phosphorus (TP) and total nitrogen (TN) in Melbourne, the required wetland size is required to be approximately 2.4% of the contributing impervious area in the **catchment**. The required wetland size for reducing 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). For a site in another location in Victoria, this area will need to be adjusted with the appropriate wetland size adjustment factor derived from either Table 2.1 or Table 2.2.

Example

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

1 From Figure 2.4, the reference wetland area needs to be 2.4% of the contributing impervious area to meet best practice objectives,
i.e. contributing impervious area = 0.5 × 500 000 = 250 000 m^2
reference wetland area = 0.024 × 250 000 = 6000 m^2.

2 The adjustment factor for the Gippsland region is computed using the wetland adjustment equation for the Gippsland region in Table 2.1:
Adjustment factor = 1.78(MAR) + 0.273
= 1.78(0.85) + 0.273 = 1.8.

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

Thus, a wetland in Gippsland (with 850 mm MAR) is required to have an area of 10 800 m^2 to give the same level of treatment as a 6000 m^2 wetland in Melbourne.

2.6 References

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