
INFORMATION BULLETIN

NUTRIENT OBJECTIVES FOR RIVERS AND STREAMS – ECOSYSTEM PROTECTION

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NUTRIENT OBJECTIVES FOR RIVERS AND STREAMS – ECOSYSTEM PROTECTION

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1 INTRODUCTION

1.1 Background

Nutrient concentrations in most Victorian streams have increased through human actions. Elevated nutrient concentrations are considered to be key contributors to nuisance growths of aquatic plants, algal blooms and associated water quality problems.

Nutrient management forms part of the overall goal of maintaining or restoring water quality, which affects stream ecological health and sustainability. The most direct measure of a stream's ecological health lies in the aquatic biota that live within it. While nutrients and other physical and chemical indicators, such as turbidity, toxicants, and oxygen, can contribute substantially to understanding of the ecosystem and its maintenance requirements, their direct relationships with ecosystem health may not always be well understood. Therefore, nutrient and other water quality objectives should be seen as only one of a range of measures used in the protection or restoration of Victoria's waterways.

*Preliminary Nutrient Guidelines for Victorian Inland Streams*¹ was published in 1995 to provide assistance to river and catchment managers in assessing the nutrient status of their water resources. To accommodate the natural, wide variety of aquatic ecosystems across Victoria, the preliminary guidelines divided the State into seven River Regions and developed nutrient guidelines for each region. The preliminary guidelines were designed to meet ecological requirements and capabilities of each region, with the goal of

maintaining or restoring ecological integrity and sustainability.

Since their publication, the preliminary guidelines have been used extensively for a variety of purposes, including deriving objectives for State Environment Protection Policies, assessing nutrient impacts from proposed and existing discharges, and for setting targets in catchment management plans.

Derivation of the guideline numbers was based on data available at the time. Although the intent behind the setting of the preliminary nutrient guidelines had not changed since their preparation, the amount of relevant, available data has. A major source of recently acquired data had been biological, chemical and physical habitat sampling undertaken by EPA as part of the federally funded National River Health Program. This resulted in detailed data from approximately 200 'reference' sites across the State. 'Reference' has been defined as 'best available' or 'least impacted' sites within a region, acknowledging that in some regions, there will not be any sites in pristine or near-pristine condition. These sites have enabled improved characterisation of the nutrient regimes of healthy sites within the regions, as well as a revisiting of the preliminary nutrient region boundaries to accommodate the biological expression of regional attributes. This document describes the development of water quality objectives for nutrients in the *State environment protection policy (Waters of Victoria)*².

1.2 Context

Victoria has endorsed the National Water Management Strategy, *Australian and New Zealand*

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*Guidelines for Fresh and Marine Water Quality*³

which uses a risk based assessment approach for developing water quality guidelines. The guidelines are termed ‘trigger values’ which are essentially alert levels, requiring follow-up assessment when breached (refer to Appendix 1 for a schematic diagram of the risk framework). Historically, guideline values were essentially ‘thresholds’ above which ecological health is likely to be compromised^{4,5}. The new risk based approach was used in the development of the nutrient objectives, as it is more meaningful than the often simplistic use of thresholds.

The nutrient objectives presented in this document are based on ecological goals. They are designed to protect the existing aquatic environment of healthy streams and to provide goals for impacted streams in a region. While ecological health is the focus, in many areas of the State a return to near-pristine conditions is neither practical nor achievable. In these areas, the nutrient objectives are representative of the better streams within the region, and provide realistic goals that accommodate regional constraints. In heavily urbanised areas nutrient objectives will not be met, and interim objectives which assist in partial restoration must be determined, as for example in the *State Environment Protection Policy (Waters of Victoria) Schedule F7, Waters of the Yarra catchment*⁶.

The nutrient status of water bodies is usually determined by either characterising concentrations, or estimating total loads. Concentrations provide a measure of the immediate availability of nutrients to algae and other plants. Nutrient loads are more applicable to endpoints, such as lakes and

reservoirs, where nutrients tend to accumulate and where sediments can be a major source of nutrients to the water column.

The intended use of the nutrient objectives necessitates their presentation in a form which is readily understandable, able to be monitored, and easily related to stream ecosystem effects, in particular algae and other plant growth. The objectives are therefore provided as concentrations rather than loads.

Objectives are provided for total phosphorus (TP) and total nitrogen (TN). There is some debate over what forms of nutrients provide the most appropriate measures of bioavailability. However, TP and TN were chosen because:

- re-mineralisation of P and N may mean that TP and TN concentrations give a better indication of ultimate bioavailability than the dissolved forms⁷;
- TP and TN have been found to relate more strongly to algal biomass than dissolved inorganic P or N⁸;
- TP and TN are the most routinely monitored forms of these nutrients. Therefore, they provided a far larger pool of data for deriving the objectives and will also be the most use to resource managers.

The setting of acceptable nutrient objectives for regions does not imply that streams with concentrations below these objectives can or should have their nutrient concentrations increased. Where concentrations are below these objectives, the default objective is the background concentration for that stream or reach.

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1.3 Scope

The scope of this document is restricted to the types of systems and conditions from which the data have been gathered. The objectives are therefore limited to perennial rivers and streams, which are reasonably well studied and understood. Many streams in the State, particularly in the north, are commonly dry, having only intermittent or unpredictable (episodic) flows. Although little is known about these streams, the limited data available indicate that they contain a rich aquatic fauna when surface water is present^{9,10}. In addition, the impact of pollutants discharged to non-flowing streams is likely to be substantially greater than that experienced by perennial streams⁹. Consequently, effluent discharges should not occur to intermittent streams.

Although there is a need for nutrient objectives for lakes and wetlands, there is a lack of sufficient, useable information for these waterbody types in Victoria. Research to address this issue should therefore be given a high priority. Many lakes are terminal systems, and adding nutrients can have very long-term consequences. To prevent nutrient enrichment problems, it is clear that no input of nutrient rich effluent should be occurring and that considerable effort should be directed towards controlling non-point source nutrient inputs.

The nutrient objectives are:

- aimed at protecting the health of the aquatic ecosystem;
- ecologically-based;
- for regions of relative nutrient homogeneity;
- not for heavily urbanised areas;
- goals for streams with elevated nutrient concentrations;
- applied to perennial streams and rivers;
- not appropriate for intermittent/episodic streams or for lakes and wetlands;
- not to be used as a value to “pollute up to”.

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2 APPROACH

2.1 Regionalisation

Within Victoria, a macroinvertebrate based (biological) regionalisation was produced for the purpose of developing biological objectives for streams across the State (Figure 1)¹¹. This regionalisation, with modification where appropriate, was used as the basis for the development of the nutrient objectives in this document. The applicability of the biological regional boundaries for nutrient management is also presented.

The biological regionalisation was used as the basis of the nutrient regionalisation for two major reasons:

- the biological regionalisation was largely concordant with EPA's preliminary nutrient guidelines¹; and
- the use of a single regionalisation across Victoria would minimise confusion and facilitate uptake of both sets of objectives.

Despite the obvious benefit of using a single regionalisation for biological and nutrient objectives across the State, it was determined that regions would be altered where the nutrient data showed this was warranted. The biological regions have been given the prefix B (for biological). The nutrient regions are given the prefix N (N1, N2, N3, and so forth).

2.2 Percentiles, Reference Sites and Data Analysis

Percentiles

The approach used in testing against the objectives was to compare a percentile from an ambient monitoring data set (for example, an annual data set with monthly sampling), with a percentile from a long-term reference data set. An important consideration when selecting percentiles for use in target-setting is that the 50th percentile (or median) gives very little information about the range of values. Higher (for example, 75th) or lower (for example, 25th) percentiles give more information on the likely highest or likely lowest value (which may impact more on the biota than median values). The further a percentile is from the median, the more information it provides. For this reason, it is often preferable to use higher percentiles when assessing monitoring data. For 12 data points (for example, one year's worth of monthly sampling data), the highest percentile that can be meaningfully used is the 75th. Although higher percentiles can be calculated, their confidence limits are too high for them to be credibly used.

Reference sites

Multiple reference sites were used to characterise the best available stream condition in each biological region using macroinvertebrate data obtained from the Victorian component of National River Health Program (NRHP). These were the same sites used for EPA's biological regionalisation of Victoria. Nutrient data from these sites allowed a characterisation of nutrient conditions within each

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region and an appraisal of the biological regions for nutrient management purposes.

Data analyses

As part of the assessment, a large amount of long term data was assembled from the Victorian Water Quality Monitoring Network (VWQMN)¹². The VWQMN database contains monthly data, from sites sampled over many years, allowing a greater level of within-site temporal characterisation than did the NRHP data set. VWQMN data were used from sites that were generally located within five kilometres of the NRHP invertebrate reference sites, with no major inputs or disturbances between the two sites.

A preliminary calculation of percentiles for TN and TP concentrations for each VWQMN site was undertaken. Subsequent to the preliminary calculations of the site data, all the nutrient data for all sites were pooled for each biological region. The long term 50th and 75th percentiles were then calculated from these data pools for each biological region (Table 1) for use in deriving the nutrient objectives.

The starting premise for developing the objectives was that the average long term value from a region's reference sites provides a reasonable value to aspire to for all sites in the region. Therefore median concentrations were calculated from the regional reference site data sets.

However, the majority of reference sites within biological regions B1, B2 and B3 (Figure 1) are genuinely high quality. Given this, despite being higher, the 75th percentiles are expected to provide sufficient protection for these regions. Results from nutrient impact and recovery studies¹³ were

available for qualifying the objectives for these regions.

Due to the high quality of the catchments, the majority of streams within regions B1-B3 are able to achieve reference, or near reference, condition with best management practices.

In contrast to regions B1, B2 and B3, the catchments of regions B4 and B5 are generally substantially impacted, with the best available sites often unacceptably degraded. As a consequence, the nutrient objectives for these more impacted regions were developed from the 50th percentiles of the long term data sets. This means that a higher proportion of the sites from these regions will trigger the objectives, reflecting the fact that even in many of the 'best available' sites there is substantial room for improvement.

The preliminary site data calculations had indicated that some of the biological regional boundaries might not be applicable to a nutrient-based regionalisation.

To test these, significance tests were undertaken on potential recombinations and divisions of regions, using two-sample t-tests¹⁴. The significance tests were undertaken on the 50th and 75th percentiles of the data for each nutrient in each relevant region.

Biological region 2 (Figure 1) appeared to contain a 'low-TN' area (Open Forest Foothills) and a 'high TN' area (Closed Forest Foothills). These two areas were tested for significant differences in TN and TP concentrations. The 'low-TN' area of biological region 2 was noted to have similar TN concentrations to biological region 3, suggesting that they could be combined to form a new region. These were also tested for significant differences in

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TN and TP concentrations. For similar reasons, the 'Coastal Plains' and 'Cleared Hills' areas of biological region 4 were also tested to verify apparent subregional differences in nutrient concentrations, as were the 'Murray' and the 'Western' Plains areas of biological region 5.

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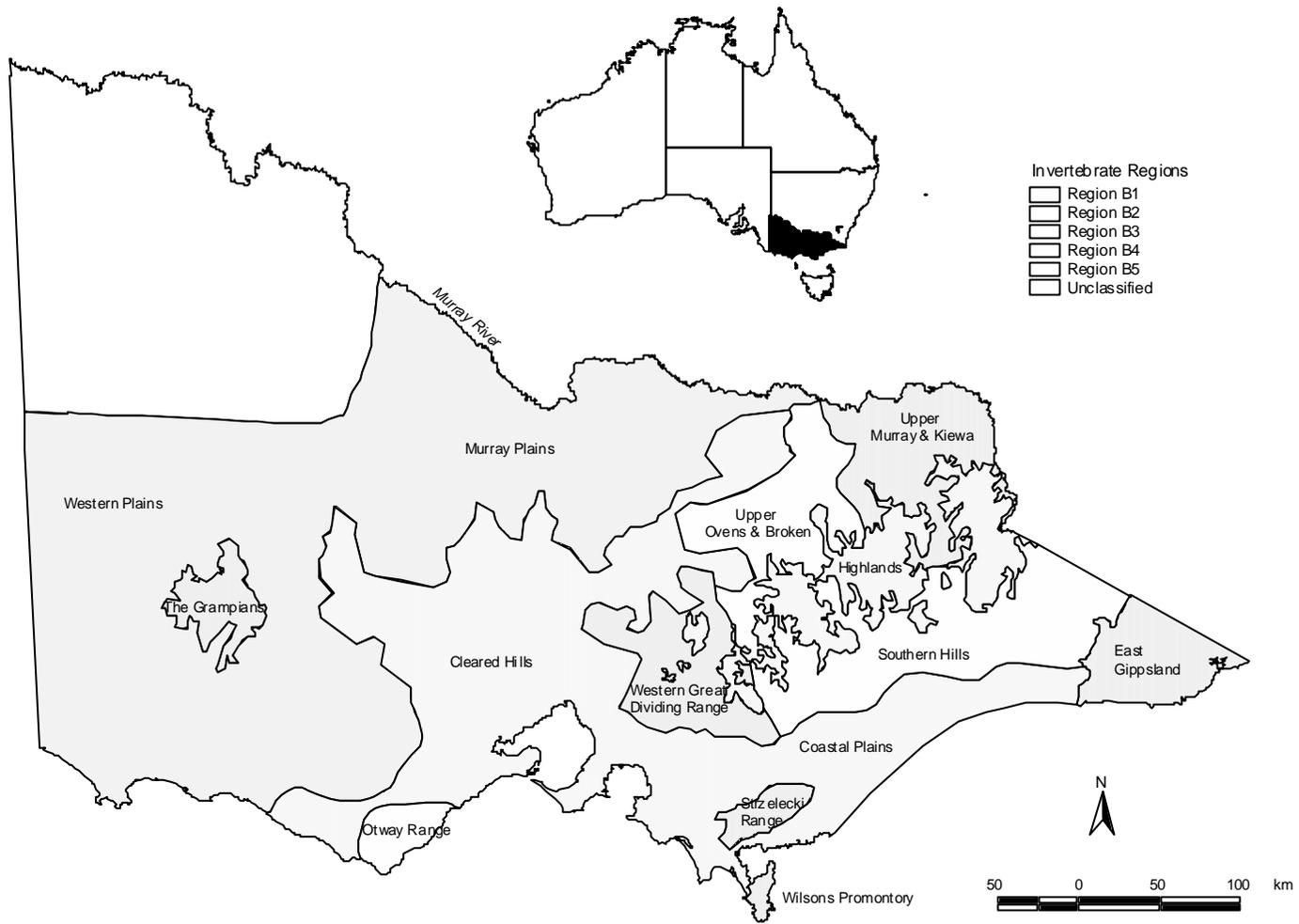


Figure 1: Biological regionalisation used for this study

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Table 1: Nutrient Data Summaries (50th and 75th Percentiles) for Biological Regions ($\mu\text{g L}^{-1}$)

	Total Phosphorus (TP)		Total Nitrogen (TN)	
	50 th	75 th	50 th	75 th
B1	nd	nd	nd	nd
B2 (all sites)	15	24	280	420
Open Forest Foothills	15	24	187	251
Closed Forest Foothills	14	25	350	490
B3	12	19	226	330
B4 (all sites)	30	54	610	960
Cleared Hills	24	39	607	957
Coastal Plains	48	86	620	970
B5 (all sites)	40	63	904	1 270
Western Plains	36	67	880	1 306
Murray Plains	43	60	950	1 220

Data sourced from VWQMN. Summary statistics use at least 5 years of data.

ND = NO DATA AVAILABLE

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3 THE NUTRIENT REGIONS

3.1 Highlands (N1) above 1000 m altitude

Biological region B1 (Figure 1) was retained unaltered as the N1 nutrient region (*Highlands*, Table 1, Figure 2), as there were no data to support any boundary changes to this region for nutrient management.

3.2 Closed Forest Foothills (N2) and Open Forest Foothills (N3)

Typically above 200 m altitude, the combined biological regions of B2 and B3 (Figure 1), cover almost the same land areas as the combined ‘Murray Foothills’ and the ‘Southern and Isolated Foothills’ River Regions from the preliminary nutrient guidelines¹. Both biological regions contain parts of each River Region. The preliminary nutrient guideline maxima for these River Regions were the same (TP 30 µg L⁻¹; TN 200 µg L⁻¹) and were based on background data and impact and recovery data¹³.

Based solely on TP concentrations (Table 1), there was little reason to divide biological regions B2 and B3. This was supported by the TP significance tests. Comparing the TN concentration percentiles however, provided strong support for changing the preliminary TN guideline values for both regions. Also, the significance tests strongly supported removing the ‘low TN’ area from biological region B2 and combining it with biological region B3.

Two new nutrient regions were therefore defined. Based on their dominant vegetation types, nutrient region N2 was named: *Closed Forest Foothills*; and nutrient region N3 has been named *Open Forest Foothills*. Nutrient region N2 (Figure 2) covers the

same area as the B2 biological region, with the exception of the Grampians and Upper Murray and Kiewa subregions, which have been placed in N3 (Table 2). Nutrient region N3 contains biological region B3 plus the Grampians and Upper Murray and Kiewa areas from B2 (Figure 1).

3.3 Cleared Hills (N4) and Coastal Plains (N5)

The substantially higher TP concentrations in the ‘Coastal’ area of B4 (Figure 1) compared to the ‘Cleared Hills’ area (Table 1) suggested that the splitting of region B4 into two nutrient regions was warranted. This was strongly supported by the significance tests. The Cleared Hills area of B4 was therefore delineated as nutrient region N4 *Cleared Hills* and the Coastal area defined as nutrient region N5 *Coastal Plains* (Table 2, Figure 2). The boundary placement for the division was aided by reasonably clear differences in the topography¹⁵ and land use¹⁶ between the regions. The *Cleared Hills* nutrient region is mostly above 200 m altitude.

3.4 Western (N6) and Murray Plains (N7)

Biological region B5 (Figure 1) could have potentially been divided into the Murray River plains and the western and southwestern rivers (Wimmera, Glenelg and Hopkins), as in the preliminary nutrient guidelines¹. The two sub-regions are different in physiography and water quality measures other than TP. The statistical significance test, however, did not support this division. The paucity of suitable sites, though, was indicated in the test outputs as limiting the test’s power to separate the subregions.

The insufficient number of sites for adequate statistical testing is a concern, as the two

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subregions appeared to require different TP objectives. In the absence of statistical evidence, this biological region was initially retained unaltered as one region. However, further interpretation of the data and consideration of the differences between the two subregions led to the division of the region into the N6, Western Plains, and N7, *Murray Plains* (Figure 2).

The tributaries of the Murray River (in the proposed Murray subregion) generally have relatively high turbidity, do not support submerged aquatic vegetation, and instead are likely to be phytoplankton dominated. When flows are low, turbidity decreases and light becomes less limiting. In this situation, phytoplankton can take advantage of elevated nutrients, possibly leading to blooms. It is during these times that nutrient limits are most required. Unfortunately, many lowland rivers in this subregion have both reduced flows and increased nutrient loads, a recipe for potential major algal bloom problems. The importance of light attenuation in these streams, its interactions with nutrient concentrations and flow conditions, and consequent influence on algal blooms is one issue that needs further investigation.

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Table 2: Composition of Nutrient Regions (SEPP WoV)

Nutrient Region	Region Name (component areas)	Biological Region
N1	Highlands	B1
N2	Closed Forest Foothills Wilsons Promontory Strzelecki Ranges East Gippsland Coast Upper Thomson, Latrobe, Yarra and Goulburn Rivers	B2
N3	Open Forest Foothills Upper Murray and Kiewa Rivers } The Grampians } Otway Ranges } Macalister to Snowy Rivers } Goulburn-Broken to Ovens Rivers }	B2 B3
N4	Cleared Hills	B4
N5	Coastal Plains	B4
N6	Western Plains	B5
N7	Murray Plains	B5

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Table 3: Key Characteristics of Nutrient Regions (SEPP WoV)

Nutrient Region	Altitude (m ASL)	Rainfall (mm) & climate	Physiography	Vegetation/Landuse	Water Quality Features ¹
N1 Highlands	>1000	>1200 subalpine to montane	Highlands. Steep mountains and valleys	Alpine woodlands (eg. snowgum) and grasslands; and tall forest (eg. alpine ash and mountain ash)	Cool water with very low turbidity and salinity
N2 Closed Forested Foothills	<1000	>1200 temperate to montane	Mountains, foothills and steep valleys	Tall closed forest (eg. mountain ash)	Cool water with very low turbidity and salinity
N3 Open Forested Foothills (Upper Murray & Kiewa, Grampians)	<1000	600 – 1200 temperate to montane	Mountains and foothills; steep and broad valleys	Tall open or closed forest (eg. mountain ash) with some clearing	Cool water with low turbidity and salinity
N3 Open Forested Foothills (Otways, Macalister to Snowy R., Goulburn to Ovens R.)	200 – 1000	700 – 1000 temperate to montane	Mountains, broad valleys	Open forest and woodland	Cool water, low turbidity and low to moderate salinity
N4 Cleared Hills	200 – 1000	300 – 1000	Hills and broad valleys	Generally cleared for dryland pasture with isolated remnant open forest and woodland	Warm water with low to moderate turbidity and salinity

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Table 3: continued

Nutrient Region	Altitude (m ASL)	Rainfall (mm) & climate	Physiography	Vegetation/Landuse	Water Quality Features ¹
N5 Coastal Plains	<200	<1000	Coastal plains of sand gravel, plains or basalt lava	Generally cleared for dryland pasture, irrigated pasture and row cropping. Some isolated remnant open forest and woodland	Warm water with low to moderate turbidity and salinity
N6 Western Plains	<200	200 – 600, except on the coast up to 1000	Broad plains of aeolian and alluvial sands or basalt lava	Generally cleared for dryland and irrigated pasture, and broadacre cropping with some woodland and mallee scrub	Warm water with moderate turbidity, high salinity and intermittent flow
N7 Murray Plains	<300	200 – 600	Alluvial plains	Generally cleared for dryland and irrigated pasture, and broadacre cropping	Warm water with high turbidity and moderate salinity

¹ Water Quality Features:

	Very low	low	moderate	high
Turbidity (NTU)	<3	3-5	10-20	20-40
Salinity (TDS)(mg ^l ⁻¹)	<30	30-100	100-1000	>1000

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4 REGIONAL NUTRIENT OBJECTIVES

The regional objectives are designed for ecosystem protection. They define concentrations above which there exists a potential risk that adverse ecological effects will occur. A potential risk will trigger either further investigation or implementation of management actions (refer to Appendix 1 for a schematic diagram of the risk framework).

An important feature of these objectives is that they are for the 75th percentiles, not median values, from current monitoring data sets. Accurate calculation of 75th percentiles requires a data set of at least 11 to 12 readings. This number of readings is well suited to assessing annual results of monthly monitoring programs. During high flow events, nutrient concentrations are likely to be elevated and individual measures are therefore likely to exceed the objective concentrations. High flow events are typically rare, however, and the use of a 75th percentile accommodates the possibility of elevated measures from sampling coinciding with these events.

In the less impacted regions (N1-N3), the nutrient objectives are based on the assumption that all sites can and should ultimately attain the quality of the regional reference sites. That is, the 75th percentiles from monitoring data at any site should be able to achieve the 75th percentiles obtained from the long-term reference site data for the region. This approach will provide adequate protection because of the high quality of the reference sites. Due to the high quality of the catchments, this goal should be achievable in the medium- to long-term, with best management practice.

In the more impacted regions (N4-N6), the poor quality of even the reference sites means greater management effort will be required to achieve ecologically healthy and sustainable rivers. The long-term goal should be to raise the quality of all streams in the region to a standard better than the current standard of many reference sites. Since 'reference site' in this document equates to 'the better sites in the region that had sufficient data', rather than 'pristine' or 'near pristine' sites, improving on reference condition aims at achieving healthy, ecologically sustainable streams, not near pristine conditions.

4.1 Highlands (N1) above 1000 m altitude

The 1995 preliminary nutrient guideline¹ concentrations proposed for N1 were primarily based on studies relating nutrient concentrations to ecosystem integrity^{17, 18, 19, 20}. Results from a study of the Thredbo River (altitude greater than 1200 m) in Kosciusko National Park, NSW¹⁸, suggested that the threshold concentrations at which no community disturbance was detected, were 20 µg L⁻¹ for total phosphorus and 150 µg L⁻¹ for total nitrogen. These findings are consistent with those of Cullen¹⁷, who found no biostimulation of attached filamentous algae in the Crackenback (Thredbo) River with phosphorus concentrations of 20 to 25 µg L⁻¹ and nitrogen concentrations typically below 150 µg L⁻¹. Obvious biostimulation occurred with a phosphorus concentration of 50 µg L⁻¹ and a nitrogen concentration of 360 µg L⁻¹. Background total phosphorus concentrations reported from Victorian alpine ski resorts¹⁹ are similar to those reported from healthy aquatic communities in Mt Stirling streams²⁰

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with median total phosphorus concentrations ranging from 10 to 14 $\mu\text{g L}^{-1}$ across six sites.

The similarity between the background concentrations in the studies cited and recently collected unpublished EPA data (median concentrations TP 13 $\mu\text{g L}^{-1}$ and TN 115 $\mu\text{g L}^{-1}$), suggested that an annual 75th percentile TP objective of 20 $\mu\text{g L}^{-1}$, and an annual 75th percentile TN objective of 150 $\mu\text{g L}^{-1}$ were applicable for nutrient region N1.

Nutrient Region N1

'Highlands'

Total Phosphorus **20 $\mu\text{g L}^{-1}$**

Total Nitrogen **150 $\mu\text{g L}^{-1}$**

75th percentile objectives from annual
monitoring data sets

4.2 **Closed Forest Foothills (N2) and Open Forest Foothills (N3)**

The long-term median TP concentrations for both regions were 15 $\mu\text{g L}^{-1}$ or below, and the 75th percentiles were approximately 25 $\mu\text{g L}^{-1}$ (Table 1). Impact and recovery data from the region¹² showed healthy invertebrate communities at sites upstream of fish farm effluent discharges, where total

phosphorus concentrations were generally in the range of 10 to 20 $\mu\text{g L}^{-1}$, and total nitrogen concentrations were up to 200 $\mu\text{g L}^{-1}$. The study also monitored sites at increasing distances downstream from the effluent discharges, with consequent dilution of the nutrients. At concentrations of 90 $\mu\text{g L}^{-1}$ total phosphorus and 600 $\mu\text{g L}^{-1}$ total nitrogen, the invertebrate community was clearly disturbed. Between 50 and 90 $\mu\text{g L}^{-1}$ total phosphorus, and 400 to 500 $\mu\text{g L}^{-1}$ total nitrogen, the biota appeared healthier, yet still disturbed, and had not recovered until total phosphorus concentrations were approximately 30 $\mu\text{g L}^{-1}$ and total nitrogen was less than 200 $\mu\text{g L}^{-1}$.

This finding also supported the contention that the majority of the reference sites in these regions were from high quality rivers and streams, and that objectives based on the long term 75th percentiles are expected to provide adequate protection for the streams of these regions. Therefore it is probable that the vast majority of the reference sites should typically pass, and an objective of 25 $\mu\text{g L}^{-1}$ is appropriate.

The N2 region (Closed Forest Foothills) has been given an annual 75th percentile TN objective of 500 $\mu\text{g L}^{-1}$, close to the long-term 75th percentile. The N3 region (Open Forest Foothills) has been given an annual 75th percentile TN objective of 350 $\mu\text{g L}^{-1}$, which is well above the long term 75th percentile for the region but in accordance with the impact and recovery data cited¹³.

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Nutrient Region N2

‘Closed Forest Foothills’

Total Phosphorus 25 µg L⁻¹

Total Nitrogen 500 µg L⁻¹

75th percentile objectives from annual
monitoring data sets

Nutrient Region N3

‘Open Forest Foothills’

Total Phosphorus 25 µg L⁻¹

Total Nitrogen 350 µg L⁻¹

75th percentile objectives from annual
monitoring data sets

4.3 Cleared Hills (N4) and Coastal Plains (N5)

Most catchments in the N4 and N5 regions have been substantially cleared, and even reference

streams within these regions are typically somewhat degraded compared to regions N2 and N3.

Nutrient region N4 (Cleared Hills) comprises once-forested hills that would have been continuous with region N2 and N3, if not for the broad-scale vegetation clearance that has occurred within this subregion. Due to its once-forested nature and general similarity with the regions, the 25 µg L⁻¹ TP objective for N2 and N3 was considered appropriate and set as the objective for the N4 nutrient region. Despite its comparatively degraded nature, more than half of the reference stream samples from the long term data set for N4 were below this concentration (Table 1), indicating that it is achievable in the medium term with on-going improvements to land use practices. The long term data sets from the region have a median TN concentration approximating 600 µg L⁻¹ (Table 1). In accordance with the methodology as adopted, and to improve water quality, this was set as the annual 75th percentile objective for TN for nutrient region N4.

Although largely cleared, the best streams in N4 do have remnant riparian vegetation. In comparison, rivers and streams in the N5 (Coastal Plains) nutrient region have generally had the riparian vegetation removed. They have been subject to substantial bed and bank modifications, river straightening, snag removal and broad-scale draining of floodplain wetlands. Most of Victoria’s population is also found in the coastal part of this region, resulting in substantial inputs of industrial and sewage wastewater and contaminated stormwater runoff. These influences are reflected in the significantly higher TP concentrations in the coastal region compared to the cleared hills region.

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In the absence of published nutrient impact and recovery data, the median TP concentration from the long term data set for this region ($48 \mu\text{g L}^{-1}$) could have been taken as the objective. Intuitively, however, a TP objective of $48 \mu\text{g L}^{-1}$ in region N5 may have been too high as a long-term objective, as even the ‘best available’ streams in this region are in poor condition, and can be improved with better land use management. Based on comparison with similar regions and expert judgement, an annual 75th percentile objective of $45 \mu\text{g L}^{-1}$ was set for nutrient region N5.

Similar to nutrient region N4, the long term TN median concentration approximates $600 \mu\text{g L}^{-1}$. In accordance with the methodology and to improve water quality, this was set as the annual 75th percentile objective for TN for nutrient region N5.

Nutrient Region N4

‘Cleared Hills’

Total Phosphorus $25 \mu\text{g L}^{-1}$

Total Nitrogen $600 \mu\text{g L}^{-1}$

75th percentile objectives from annual monitoring data sets

Nutrient Region N5

‘Coastal Plains’

Total Phosphorus $45 \mu\text{g L}^{-1}$

Total Nitrogen $600 \mu\text{g L}^{-1}$

75th percentile objectives from annual monitoring data sets

4.4 Western (N6) and Murray Plains (N7)

The Wimmera River, in the Western Plains, is the best studied river in this region and provides the most ecological insight. It is nutrient enriched and has been prone to phytoplankton blooms²¹. Light is a very important factor in plant productivity in the Wimmera River, and flow is likely to be the key to water clarity. The objectives derived, therefore, will be most important when there is low turbidity and consequent high light levels. Substantial research over the years has recommended an appropriate environmental flow be maintained in the mainstream Wimmera River to improve water quality and to maintain and restore biological values.

The floodplain rivers in the Western Plains are typically not as turbid and support substantial growths of macrophytes compared to the Murray River tributaries. The long term median concentrations for TP and TN in biological region B5 were generally around $40 \mu\text{g L}^{-1}$ and $900 \mu\text{g L}^{-1}$,

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respectively (Table 1). These are expected to be achievable with best management practices and should provide adequate protection for the stream ecosystems in the Western Plains. They have consequently been set as the annual monitoring 75th percentile objectives for the N6 nutrient region.

Data are limited for the Murray Plains, nonetheless that which is available suggests that TP concentrations around 45 to 50 $\mu\text{g L}^{-1}$ should be expected at the best available sites. While the differences between the Western and Murray plains were found to be non-significant (see section 3.4), best available judgement suggested that an objective for TP of 45 $\mu\text{g L}^{-1}$ should provide adequate protection for the stream ecosystems in the Murray Plains (Nutrient Region N7).

The very northwest of the State (Figure 2) cannot be classified due to the lack of data and to the lack of permanent flowing rivers and streams.

Nutrient Region N7

‘Murray Plains’

Total Phosphorus 45 $\mu\text{g L}^{-1}$

Total Nitrogen 900 $\mu\text{g L}^{-1}$

75th percentile objectives from annual
monitoring data sets

Nutrient Region N6

‘Western Plains’

Total Phosphorus 40 $\mu\text{g L}^{-1}$

Total Nitrogen 900 $\mu\text{g L}^{-1}$

75th percentile objectives from annual
monitoring data sets

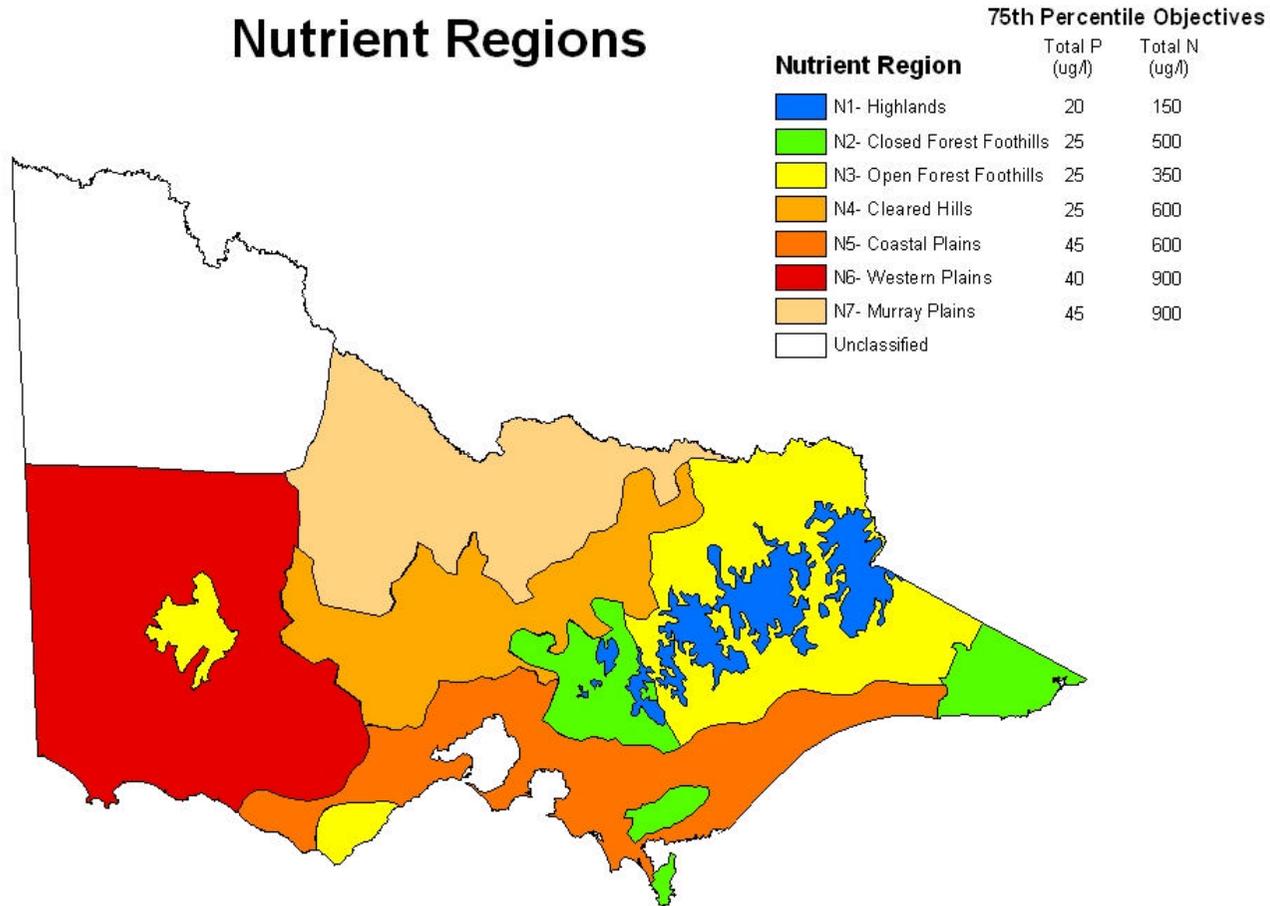


Figure 2: Nutrient Regions and their objectives (SEPP WoV)

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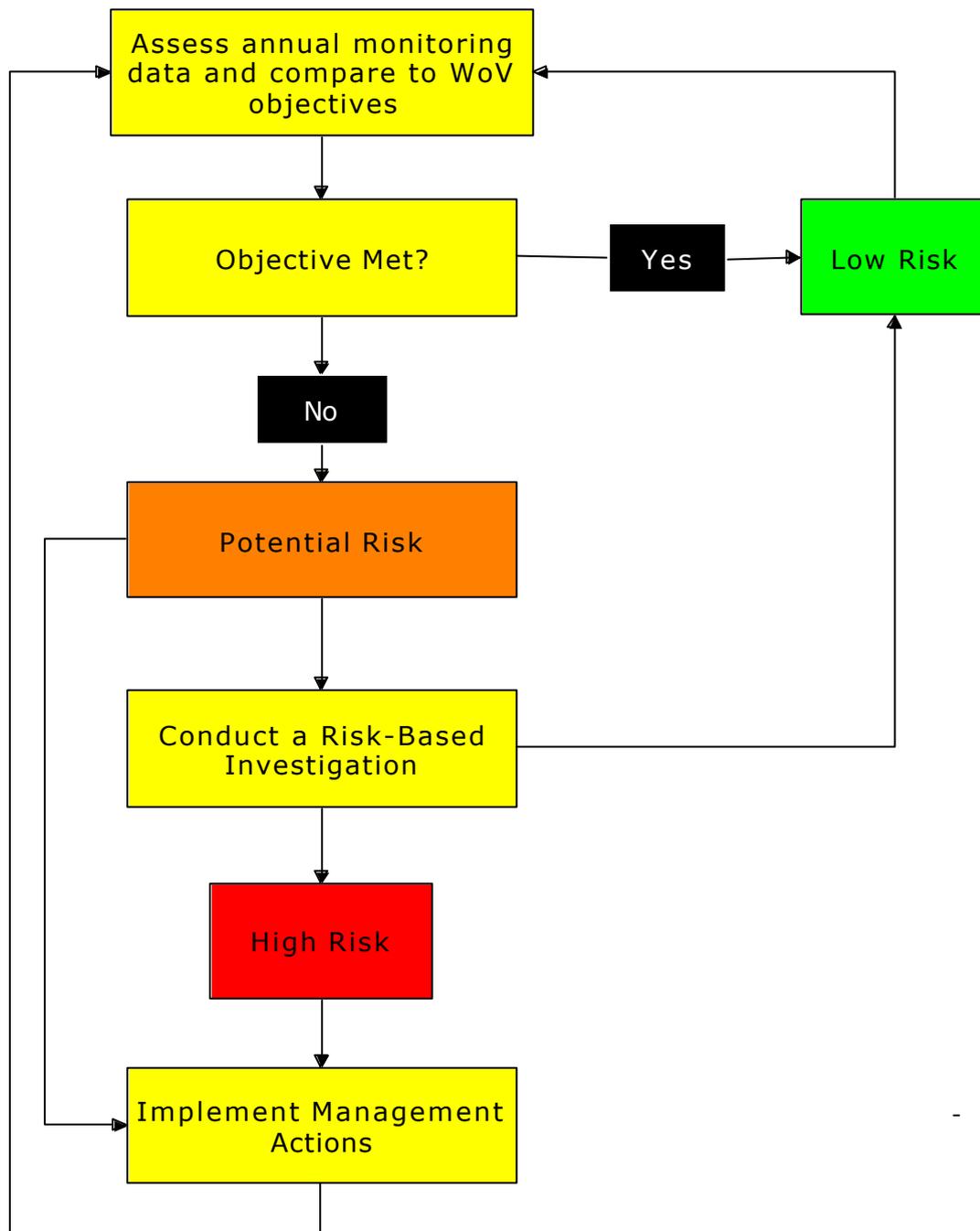
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APPENDIX 1: RISK-BASED DECISION FRAMEWORK (SEPP WOVS)



For more details on the risk-based approach used by EPA, refer to: Environment Protection Authority Victoria, *Risk Assessment Approach – Ecosystem Protection*, Publication 790.1, 2003.