Nitrogen species distribution in groundwater: A review of historical data with recent sampling in the Gippsland

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Introduction

In agricultural regions diffuse pollution by nitrate is considered one of the main causes of groundwater quality deterioration (Dillion et al. 1991). For agricultural systems that are pasture based, the input loads (e.g. fertiliser, cow dung and urine) can result in loss of nutrients. Hence, shallow groundwater aquifers in agricultural areas are susceptible to nitrate contamination from losses of N by leaching.

Methodology, Results & Discussion

Existing State Observation Bore Network (SOBN) groundwater data for the Gippsland region was collated from the Victorian Water Measurement Information System (WMIS) and mapped to show the spatial distribution of nitrogen species (nitrate, nitrite, total nitrogen). In addition, 24 bores selected from the existing network were sampled in December 2015 and analysed for nutrients in groundwater. These bores are located in the dairy farming areas in West Gippsland.

The NO_3-N concentrations in the Gippsland region groundwater varied considerably from East Gippsland to West Gippsland (**Figure 1**), although the chemistry data was limited both spatially and temporally.

- The **129 bores** in West Gippsland had NO_3-N concentrations ranging from 0.1 to 20 mg/l and **85%** of these were **< 1 mg/l NO_3-N**. The **30 bores** from East Gippsland had concentrations from 0.02 to 99.4 mg/l NO_3-N. Only **20%** of these bores had concentrations above the Australian and New Zealand Guidelines for Water Quality (ANZEEC) limit of 10 mg/l (**Figure 2**). Bores with NO_3-N concentrations higher than this limit are mostly shallow and screened in Alluvium (**Table 1**).
- In all confined or deeper aquifers groundwater bore samples, the concentrations were found to decrease further compared to shallow groundwater (bores with screen <25 m). Wetter soils are prone to nitrate reduction, as they typically provide restricted oxygen availability and sufficient electron donors (Follett 2008). Detail discussion available in Adelana & Holmberg (2016).

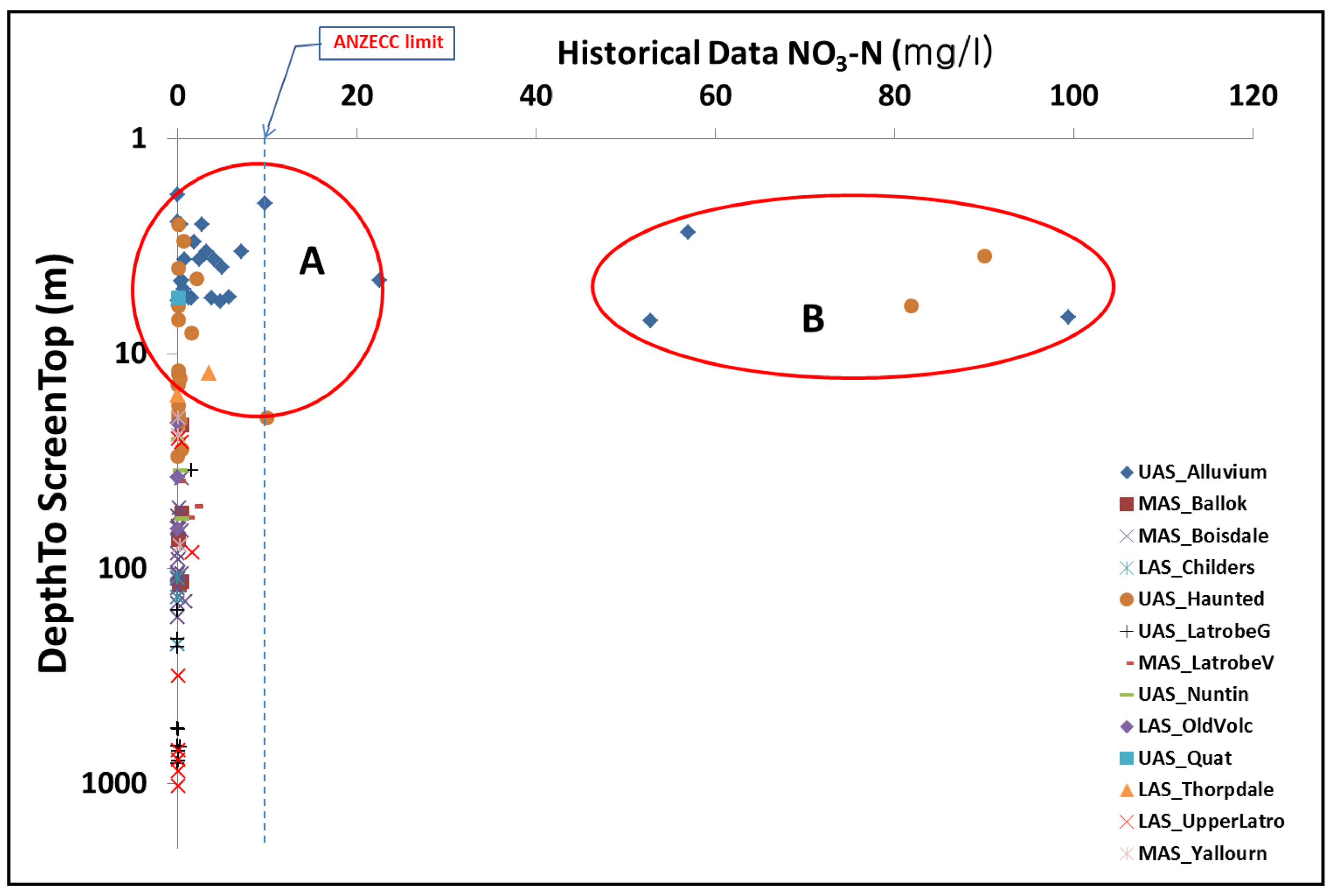

Figure 2. Depth (below ground surface) to the top of the screen is plotted against nitrate concentration levels in groundwater. Bores are generally screened in aquifers where there is sufficient water to sustain its production. Bores regarded as shallow, in this study, are those less than 25 m depth or screened <25 m below ground surface. This category picked two groups (A & B) based on low or relatively high nitrate concentration levels. (Note: There are 3 aquifer systems in the Gippsland basin, viz: Upper aquifer (UAS), Lower middle aquifer (MAS) and Lower aquifers (LAS)

Conclusion

There was variation in the concentrations of dissolved N-species in the groundwater within the Gippsland area (from West to East) based on historical WMIS and recently measured data. Although recent groundwater sampling in the south-western Gippsland recorded concentrations within the lower nitrate range of the historical (WMIS) data, piezometers within a previously established dairy farm had concentrations close to the ANZECC guideline limit. These results suggest that land use practices in the area need to be monitored. Analysis of monitored N-species concentrations with isotopic compositions under various land uses and environmental conditions would inform an evaluation of nitrogen loading in the landscape.

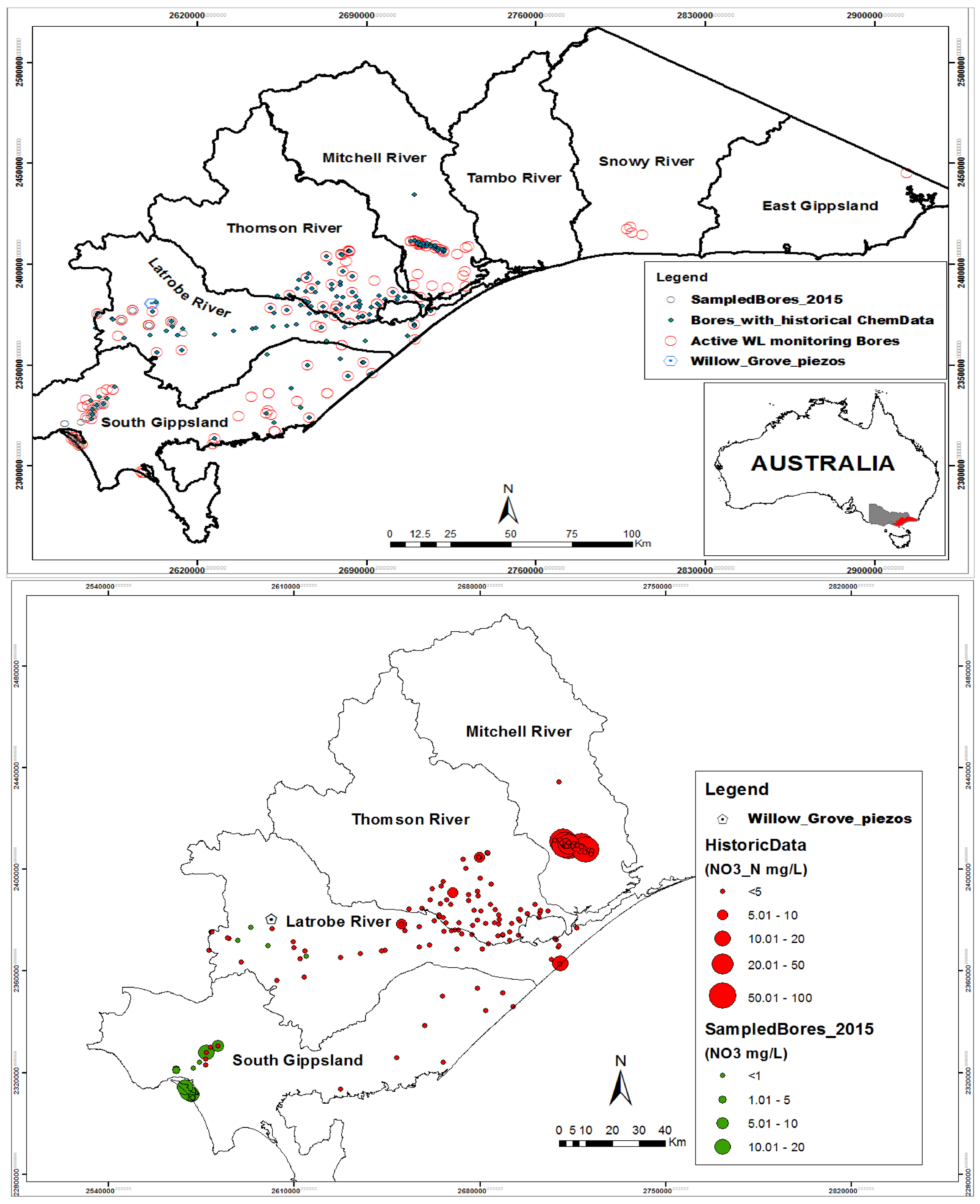

Figure 1. Top: Gippsland River Basins with bore distribution and data; Bottom: Spatial distribution of nitrate levels in bores (historical & recent data). Note the different measurement units for nitrate: milli-equivalent of compound N is equivalent to 62 mg when expressed as NO_3^-.

Table 1. Summary statistics of N-species concentrations in groundwater (by aquifers) in the Gippsland[A].

AQUIFER SYSTEM	NITRATE-NITROGEN (mg/l)				TOTAL NITROGEN (mg/l)			
	(Count)	(Min)	(Max)	(Mean)	(Count)	(Min)	(Max)	(Mean)
Upper Aquifer System	**86**	**0.02**	**99.4**	**6.0**	**30**	**0.1**	**36**	**3.2**
Alluvium	27	0.03	99.4	10.7				
Haunted Hills	45	0.02	90.0	4.5	24	0.1	36	2.4
Nuntin Clay	3	0.15	0.5	0.3	1	3.3	3.3	3.3
Quaternary	9	0.05	7.0	0.9	5	0.2	30	7.1
Unknown	2	0.15	20.0	10.1				
Mid Aquifer System	**34**	**0.01**	**2.9**	**0.4**	**14**	**0.1**	**5**	**1.2**
Balook	5	0.15	0.5	0.4	4	0.3	3.4	1.6
Boisdale	12	0.01	2.9	0.4				
Boisdale	11	0.01	0.9	0.3	9	0.1	1.4	0.6
Latrobe Valley	3	0.09	2.1	1.1				
Yallourn	3	0.15	0.3	0.2	1	5	5	5.0
Lower Aquifer System	**36**	**0.01**	**4.1**	**0.4**	**3**	**0.1**	**0.1**	**0.1**
Childers	3	0.02	0.0	0.0				
Latrobe Group	14	0.01	1.6	0.2				
Older Volcanics	6	0.01	0.0	0.0				
Seaspray Sand	1	0.19	0.2	0.2				
Thorpdale Volcanics	2	0.01	3.5	1.8	1	0.1	0.1	0.1
Unknown	2	0.01	4.1	2.0				
Upper Latrobe	7	0.15	1.7	0.4	1	0.1	0.1	0.1
Upper Latrobe	1	0.15	0.2	0.2	1	0.1	0.1	0.1
Basement Aquifer System	**3**	**0.01**	**2.3**	**0.8**				
Strzelecki	3	0.01	2.3	0.8				
Grand Total	**159**	**0.01**	**99.4**	**3.4**	**47**	**0.1**	**36**	**2.4**

[A] Bores in these aquifers mostly show nitrite-nitrogen levels < 0.01 mg/l and NH_4 data very scanty, as such, are not presented in the table.

References

Adelana M, Holmberg M (2016) Report on the methodology for quantifying nitrogen transport and transformations below the root zone and in shallow groundwater. Agriculture Research Technical Report for Project CMI No: 105512 (no.2). Department of Economic Development, Jobs, Transport & Resources, Melbourne.

Dillon PJ, Ragusa SR, Richardson SB (1991) Biochemistry of a plume of nitrate-contaminated groundwater. Nitrate Contamination: Exposure, Consequence and Control, 173-180.

Follett RF (2008) Transformation and transport processes of nitrogen in agricultural systems. Nitrogen in the Environment: Sources, Problems, and Management, 19-50.

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