



**Addendum to the Assessment of Groundwater  
Resources in the Western Davenport Plains Water  
Control District  
Designation of well protection zones**

**E301561**

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## Document information

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	Designation of well protection zones
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## Revision history

### Revision 0

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# 1. Introduction

The Northern Territory Government is finalising a Water Allocation Plan (WAP) for surface water and groundwater in the Western Davenport Water Control District (NRETAS, 2010).

One of the key contents of the WAP is water allocation and licensing. Amongst a range of issues under this subject is setting rules via a risk analysis on varying levels of extraction and identifying the assumptions on which such rules are applied. One rule is the setting of well or bore protection zones (WPZs). Such WPZs are applied to safeguard other users and the environment from derogation and deterioration as a result of the pumping drawdown of the water-table, and mobilisation and capture of potential contaminants.

Entura (ex-Hydro Tasmania Consulting) were commissioned by NRETAS on 10th January 2011 to provide confirmation of the recommendation of buffer zones as currently countenanced in the draft WAP.

These buffer zones are recommended as follows:

- 400 m from production bores for new bores capable of yielding 20 L/s or more; and,
- 200 m from potential pollution sources.

The relevant excerpts from Section 9.2 “Matters to consider when granting Licences and Permits” of the WAP are:

- V The capacity of proposed production bore/s and their location relative to existing operational bore/s, and the provision of evidence demonstrating minimum potential for impact (it being recognised for the purposes of the Plan that it is generally undesirable for a bore with a capacity of over 20 L/s to be constructed within 400 m of an existing operational bore)
- VI The location of a proposed production bore relative to a potential pollution source, including without limitation, old and current landfill sites, septic tanks and/or unbunded fuel or chemical depots and the provision of evidence demonstrating minimum potential for water quality impacts (it being recognised for the purposes of the Plan that it is generally undesirable for a bore to be constructed within 200 m of such a source)

## 2. Well Protection Zones – definition

A well protection zone (WPZ) defines a zone surrounding a public water supply borefield through which groundwater moves toward and reaches a borefield, which can then be designated as a planning instrument to control and restrict land use activities. The areas to be included in the WPZ are the zone of influence (i.e. the area impacted by drawdown) and the zone of contribution (i.e. the area that recharges or contributes water to the borefield). Private bores, septic systems drainage, and industrial activities should be excluded from within such a WPZ.

Groundwater hydraulic parameters that are important in assessing a WPZ are:

- hydraulic conductivity, both vertical and horizontal,  $K_v$  and  $K_h$ ;
- effective porosity (specific yield,  $S_y$ ) of the vadose and saturated zones; and,
- depth to groundwater (i.e. thickness of vadose zone).

### 2.1 WPZs applied to prevent ingress of contaminants

In particular, the risk of viral and bacterial, and organic contamination is reduced with increasing distance between a source (e.g. a septic absorption trench) and a receptor (e.g. a bore), resulting in greater groundwater flow travel-times ('travel-times'). Approximately 100 days is considered to be an adequate residence time for the 99.999 % ( $5 \times \log_{10}$ ) decay and removal of pathogens and viruses. AGT (2003) provides background and references to national and international studies that support this assertion.

Scientifically defensible designations of well protection zones (WPZs) for several public water supply borefields operated by Power and Water were carried out in the Northern Territory (AGT, 2003 and AGT, 2007). On the basis of 100 days and 500 days<sup>1</sup> travel-times defined by groundwater modelling, WPZs were designated around these borefields. Salient results and recommendations (including verbatim statements) from these studies are given below.

#### 2.1.1 Darwin Rural area (AGT, 2003)

- Fractured rock, weathered dolomite aquifer (Mullaman Beds / Koolpinyah Dolomite)
- Transmissivity,  $T = 1,000 \text{ m}^2/\text{day}$  (adopted for the MODFLOW/MT3D saturated flow groundwater model)
- At a pumping rate of 40 L/s, and with a 100 days travel-time, the radial distances to certain production bores was between 300 m and 410 m
- Radial distances between approximately 300 m and 550 m are required for all bores for a calculated 100 days time-time; (the latter distance at a pumping rate of 80 L/s)
- Distances of greater than 200 m are required to provide long-term protection from normally operating septic systems in the absence of potential short-circuits.
- With a recommended 100 days travel-time, a minimum exclusion zone (WPZ) of 400 m is indicated for McMinns Borefield. This may be considered a conservative guideline as it neither accounts for the time to infiltrate through the vadose zone, nor through the

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<sup>1</sup> The distances travelled from source to receptor by a 'captured' groundwater particle for 100 and 500 days' travel-times.

Cretaceous sediments; and, does not account for flow/contaminant dilution at the bore-head.

### 2.1.2 Katherine, Mataranka, Larrimah and Elliott (AGT, 2007)

- Katherine - fractured rock limestone including karst aquifer (Tindal Limestone); Mataranka - fractured rock limestone aquifer (Tindal Limestone) and low-yielding basalt (Antrim Plateau Volcanics); Larrimah - fractured rock calcarenite and chert limestone aquifer (Tindal Limestone); Elliott - cavernous and fractured sedimentary rock aquifer (Anthony Lagoon Beds and Gum Ridge Formation)
- Transmissivity,  $T = 5,000 \text{ m}^2/\text{day}$  (Katherine Mataranka);  $T = 2,500 \text{ m}^2/\text{day}$  (Larrimah );  $T = 100 \text{ m}^2/\text{day}$  (Elliott) (all adopted for the FEFLOW saturated flow groundwater model);
- The ambient land use in the study areas identified pathogens and viruses as the most problematic contaminants
- Based on 100 days travel-times within the aquifer (saturated flow) derived from numerical (FEFLOW)<sup>2</sup> and analytical modelling particle tracking, conservative WPZs were recommended
- The results gave values ranging from 110 m (at Elliott), 1,000 m (at Larrimah) to 5,200 m (at Katherine)
- Active management of potential contaminant sources is required within the 100 days travel-time zones and that such zones should be used as a planning instrument for the enforcement of regulatory controls
- Depending on the aquifer type, 'inappropriate' land use practices in a 'buffer zone' beyond the WPZ and application of the 'precautionary principle' should be considered on an aquifer basis.
- In recognition of groundwater model uncertainties, 500 days' distance travel times were assigned to help define outer ('buffer') protection zones (AGT, 2007).
- Vadose zone analytical modelling (for Larrimah and Elliott) indicated vertical travel times to the water table were of the order of hundreds of days, and the designation of WPZs might be considered as an academic exercise.

## 2.2 WPZs applied to minimise hydraulic interference between production bores

WPZs may be applied around borefields, especially public water supply borefields in relation to other groundwater users (e.g. mine, stock or individual domestic supply bores) to avoid or minimise hydraulic interference whereby either or both parties sustainability of supply might be compromised or derogated.

### 2.2.1 Alekarenge Farm (AGT, 2007a)

AGT (2007a) undertook groundwater modelling of the then proposed Alekarenge Farm using a transmissivity,  $T$  of  $430 \text{ m}^2/\text{day}$  and storativity,  $S = 0.004$  for the Cambrian aquifer; the following pertinent prediction was made:

- at a production bore spacing of 400 m and a bore pumping at 25 L/s,  $S_{\text{max}} = 13 \text{ m}$  in the aquifer immediately adjacent the bore casing.

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<sup>2</sup> In the FEFLOW modelling and risk assessment, a worst case scenario of no attenuation of contaminants has been assumed.

Subsequent analysis of operational pumpage (HTC, 2010) from the established farm has indicated that transmissivity, T is generally less than model predictions for the Cambrian aquifers (except in production bores RNs 18117 and 18441) and sometimes one; up two orders of magnitude less than model predictions for storativity, S. Whilst this means that operationally greater mutual drawdown interference may be expected, the onset of steady-state conditions through leakage from the Cainozoic aquifers (where present) should not lead to any significant expansion of this drawdown over the proceeding years, but cumulative pumping impacts from several bores may.

HTC (2010) proceeded to recommend a more conservative production bore separation of 600 to 800 m to the borefield operator. It should be stressed that this is an operational recommendation that takes account of operational rules and potential energy savings. It does not compromise the original finding of 400 m separation in terms of borefield sustainability.

### 3. Application of WPZs to the WDP

In the absence of specific groundwater hydraulic parameters for the WDP, transmissivity, T (Table 3-1) is used as a surrogate to compare with the previous studies described above.

**Table 3-1**  
**Summary of Broad-scale Transmissivity ranges and values for Aquifers reported across the WDP**

Transmissivity, T (m <sup>2</sup> /day)	Aquifer	Location	Source (all reported in HTC, 2009)
50	Cainozoic	Warrabri / Alekarengge	Verhoeven and Read, 1978
500	Cambrian	Warrabri / Alekarengge	Verhoeven and Read, 1978
150 - 5,000	Cainozoic / Cambrian	Singleton / Murray Downs Stations	Carosone, 1990
69	'upper' Chabalowe Formation	Iliyarne ALT	NRETA (Sumner; 2008)
250	Arrinthrunga Formation (dolomite)	northern boundary of Neutral Junction	NRETA (Pye; 2008)

With a range of transmissivity values from 70 to 5,000 m<sup>2</sup>/day and a median of about 500 m<sup>2</sup>/day it is considered that, simplistically, a WPZ of some 400 m is adequate for high-yielding bores completed in the main (Cainozoic and Cambrian) aquifers of the WDP.

Typically these aquifers do not yield more than 30 L/s from bores completed in chalcedony/silcrete of the Cainozoic aquifers, and do not yield more than 20 - 30 L/s from bores completed in the Georgina Basin and Wiso Basin aquifers. The Davenport inlier and Arunta Blocks tend to have variable yielding bores (maximum 20 L/s, but more commonly not more than 5 L/s).

Hence, the productive aquifers of greater beneficial use across the WDP that are being and will be further targeted for development have similar or lower yields to those discussed in

AGT (2003 and 2007). They also have similar or lower transmissivities than those reported in *ibid*. These prior studies indicate WPZs generally in the range 200m to 400 m (except in the Tindal Limestone of Katherine that is characterised by karst and urban development).

Thus, it seems reasonable to adopt these similar control buffers as WPZs for the WDP WAP. Therefore the following WPZs are recommended for adoption by the WDP WAP:

- no bores to be completed within 200 m of potential pollution sources that typically may be found in this region (such as sewerage septic disposal systems; cattle dips, fuel stores, sludge and landfill sites, etc.); and,
- no bores having a yield of 20 L/s and greater to be completed within 400 m of an existing production bore.

## 4. Caveat to the Recommendations

To designate site-specific WPZs, effective modelling of localized groundwater flow in the vicinity of a borefield is essential for reliable estimation of contaminant travel time. This may be analytical or numerical or a combination of both to verify travel-time estimates including travel-times by vertical infiltration through the vadose zone to the water-table.

Depending on the aquifer type, “inappropriate” land use practices in a ‘buffer zone’ beyond the WPZ and application of the ‘precautionary principle’ should be considered on an aquifer basis to the expansion of the analysed WPZ.

Defectively constructed, corroded and /or old ‘leaky’ bores have the potential to ‘short-circuit’ the natural buffering capacity of the soil / rock, and to act as conduits for transport of contaminants from the vadose zone and / or shallow aquifers to the underlying producing aquifer. Hence, the proper completion of production bores (and abandonment of investigation and disused bores) is of the utmost importance to prevent aquifer contamination.

## 5. References

Australian Groundwater Technologies / Crinalis International / CSIRO Land and Water, Perth / Lisdon Associates, 2003. *Review of Potential for Domestic Septage Contamination of Groundwater in Darwin Rural Area*. Prepared for Power and Water Corporation, Department of Infrastructure, Planning and Environment, and Department of Health and Community Services, Northern Territory

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