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Project No. 293
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WET TROPICS MAJOR INTEGRATED PROJECT

GROUNDWATER FLOW ASSESSMENT UPDATE

SYNDICATE ROAD AND LEICHHARDT ROAD

TULLY RIVER CATCHMENT

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1.0 INTRODUCTION

Rob Lait and Associates Pty Ltd (RLA) was requested by the Wet Tropics Major Integrated Project (WTMIP) to update the assessment of the directions and volumes of groundwater flow measured using piezometers at two sites in the Tully River catchment – Syndicate Road and Leichhardt Road.

This update follows on from an RLA report on groundwater flow conditions for the two sites, dated November 2020.

WTMIP project staff collected additional temporal groundwater level and groundwater chemistry parameters from each of the piezometers from November 2020 until the end of March 2021. The data from these measurements were used to re-assess groundwater behaviour at each site.

As this is a groundwater assessment it is pointed out that no chemistry data from sampling sites within the drains were used.

The objectives of this report were to:

- Provide guidance to the WTMIP team on the direction of groundwater flow at the two sites that would lead to a better understanding of the dissolved inorganic nitrogen (DIN) under different land use practices; and
- Determine whether further groundwater testing using the piezometers was needed to add to that understanding.

2.0 PIEZOMETER LOCATIONS

Figure 1 shows the locations of the Syndicate Road piezometers.

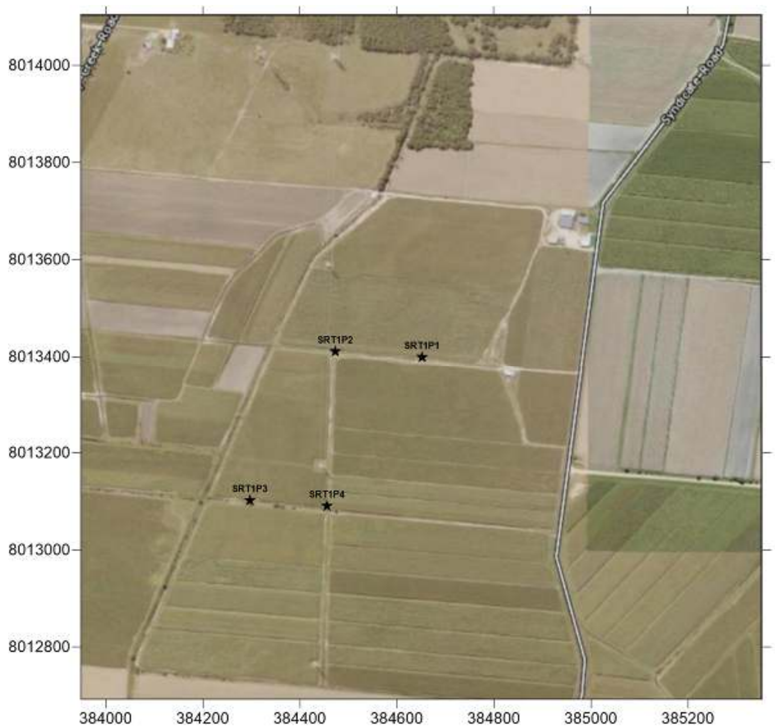


Figure 1: Locations of Syndicate Road Piezometers

Figure 2 shows the locations of the Leichhardt Road piezometers.

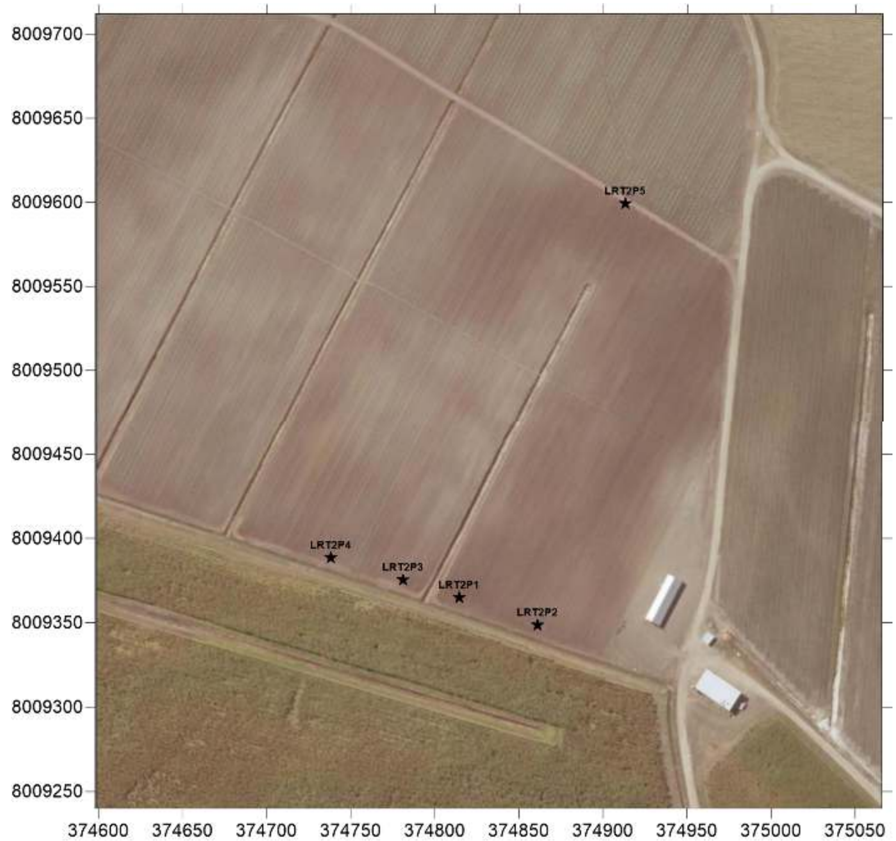


Figure 2: Locations of Leichhardt Road Piezometers

All piezometers installed for the project are lined with 50mm internal diameter PVC monitoring pipe, screened from about 1m below ground level to the total depth of the borehole. Each piezometer was filter packed over the extent of the screen and completed with a cement grout annular seal from ground surface to 1m depth.

3.0 GROUNDWATER DATA INTERPRETATION

Groundwater levels are measured in the piezometers at either bi-monthly or monthly frequency.

3.1 Groundwater level behaviour

Figure 3 shows the depth to groundwater in the Leichhardt Road piezometers, plotted against daily rainfall data from Euramo Bureau of Meteorology Station (BOM) 32167 (available from the BOM website).

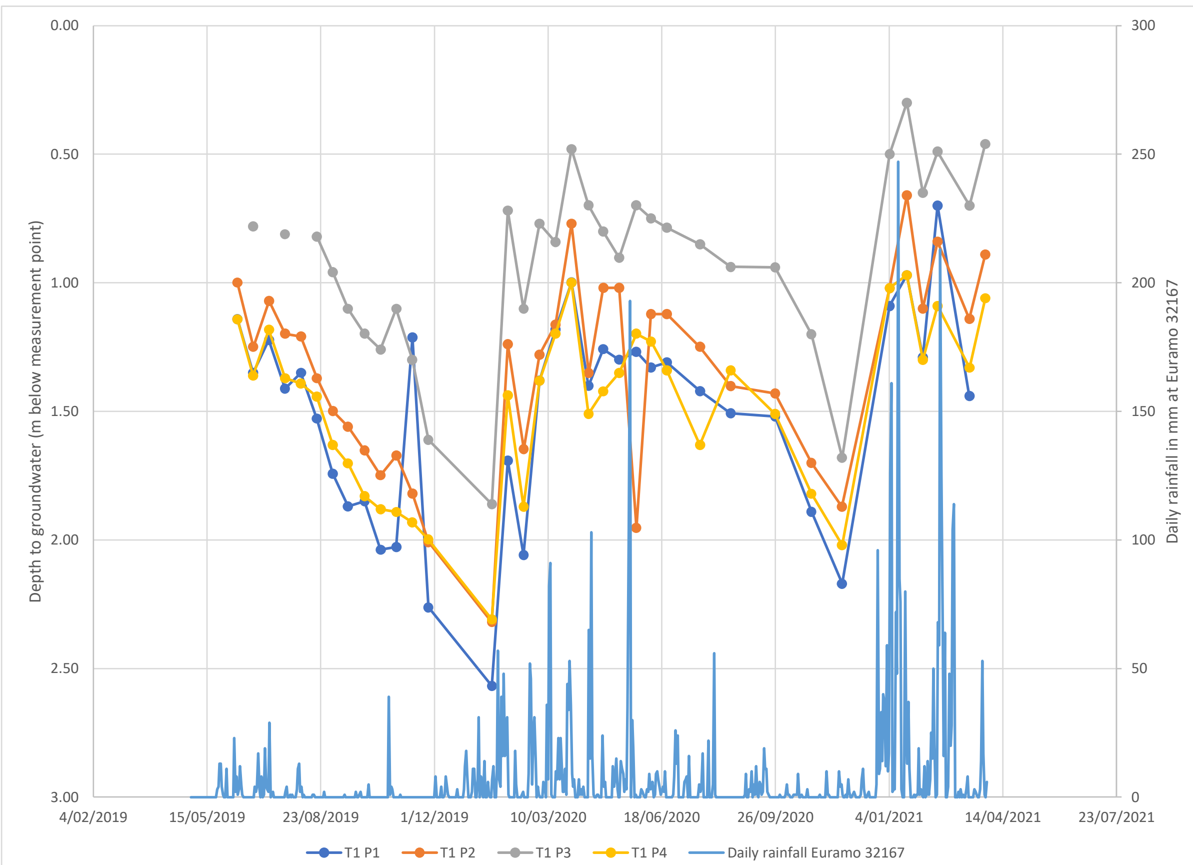


Figure 3: Chart of depth to groundwater at Syndicate Road versus Daily Rainfall from BOM Station 32167 (Euramo)

The water level elevation traces for each piezometer exhibit similar shapes and amplitudes of response to recharging rainfall. A seasonal variation of about 2m is evident from the water level elevation plots.

Figure 4 shows the depth to groundwater in the Leichhardt Road piezometers, plotted against daily rainfall data from Euramo (BOM station 32167).

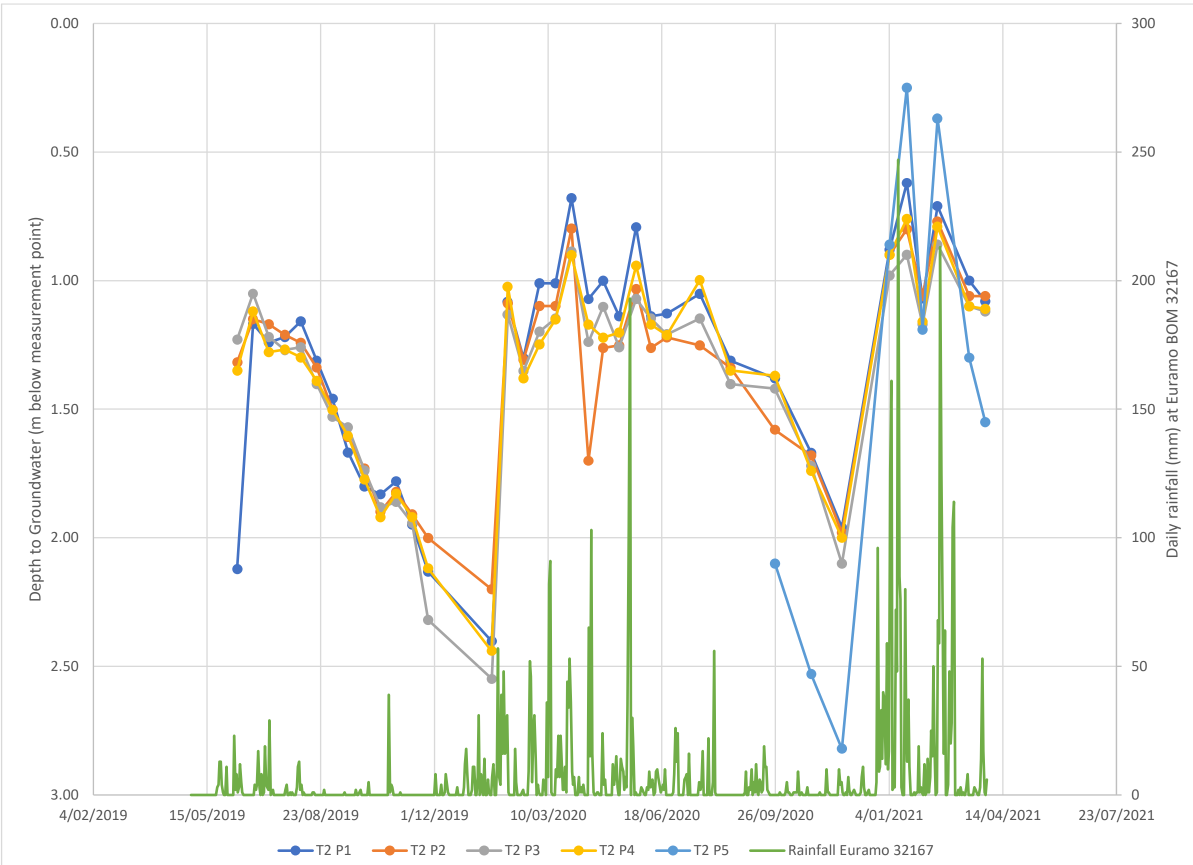


Figure 4: Chart of depth to groundwater at Leichhardt Road versus Daily Rainfall from BOM Station 32167 (Euramo)

The depth to groundwater traces for each piezometer exhibit similar shapes and amplitudes of response to recharging rainfall. A seasonal variation of 2 to 2.5 m is evident at Leichhardt Road.

It is evident from Figures 3 and 4 that groundwater levels at both sites rise rapidly in response to incident rainfall, and conversely groundwater levels begin to fall as soon as rainfall ceases.

3.2 Groundwater flow directions

Groundwater flow directions were assessed by contouring the potentiometric surface[1] contours from the piezometer water level elevation data. The lowest groundwater level condition over the period of records occurred on 20th January 2020 and the highest groundwater level condition over the period of records occurred on 19th January 2021. Therefore, it is instructive to examine potentiometric surface contour maps for these two dates, as well as that for 28th September 2020 (reported previously).

Data extracted from the Department of Natural Resources and Mines (DNRM) water monitoring data base shows that it is not unusual for groundwater levels to be very low in late December / early January prior to the onset of the wet season proper. A chart of groundwater level in DNRM groundwater monitoring bore Registered Number 11300015, located at Lihs Road some 4km to the west of the Syndicate Road site, is shown in Figure 5 to illustrate this point. Figure 5 also illustrates that the water level measuring technique used by the WTMIP team is sound and appropriate.

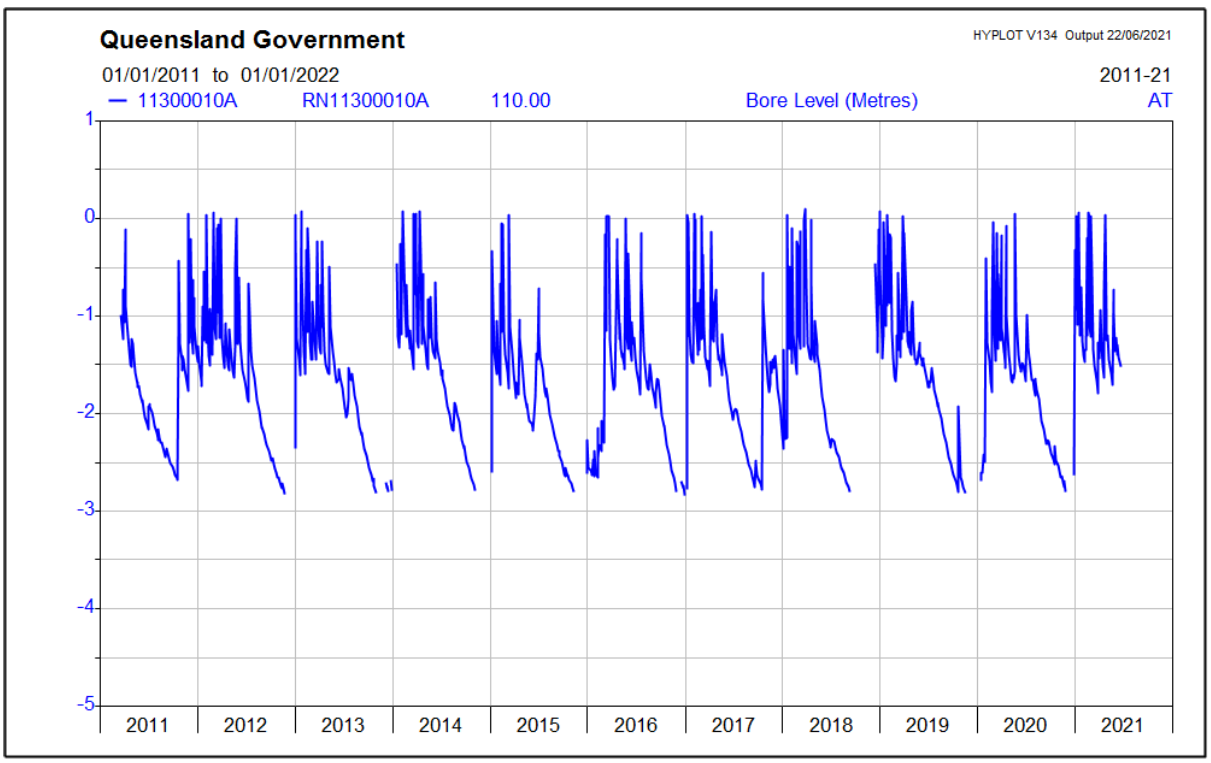


Figure 5: Chart of Groundwater Level Behaviour in Registered Number 11300015 (Lihs Road)

[1] The potentiometric surface is an imaginary surface that defines the top of the water table.

Syndicate Road

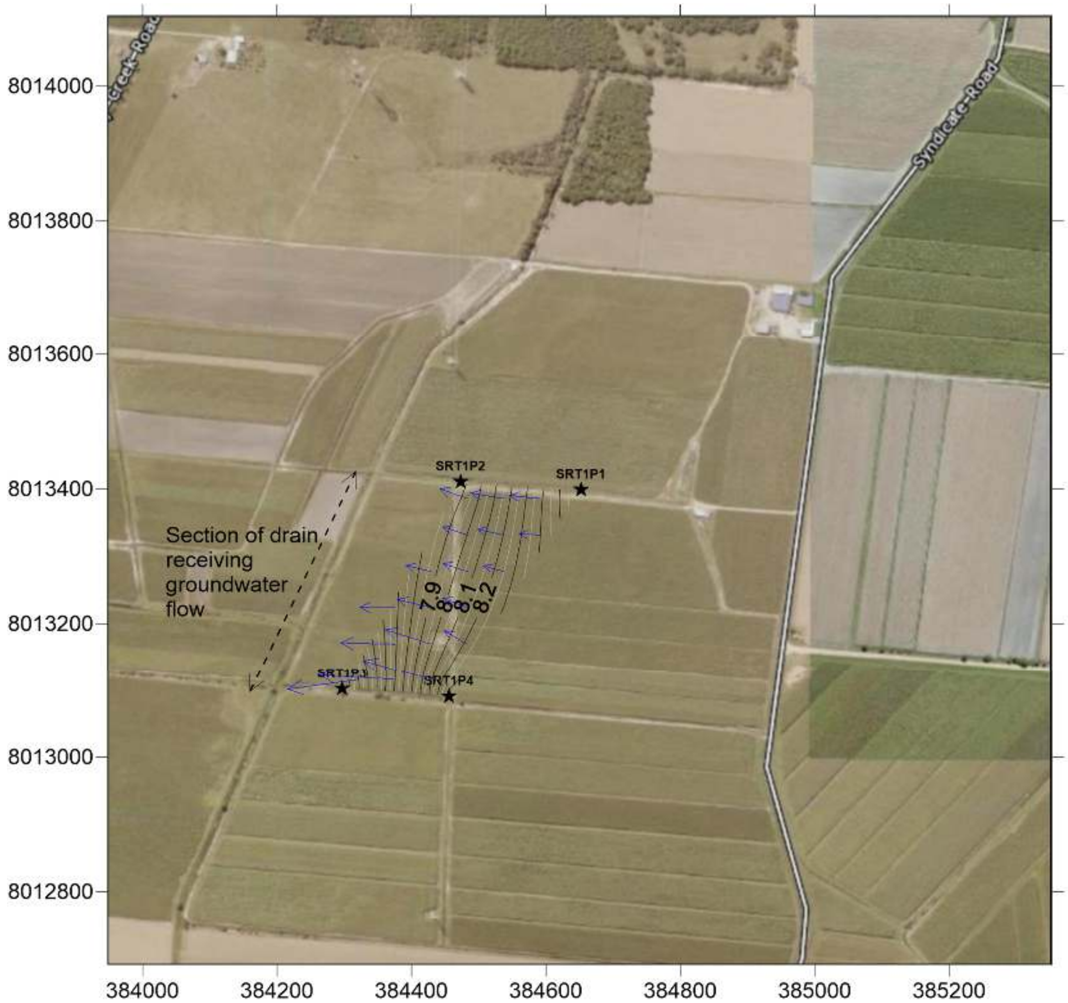
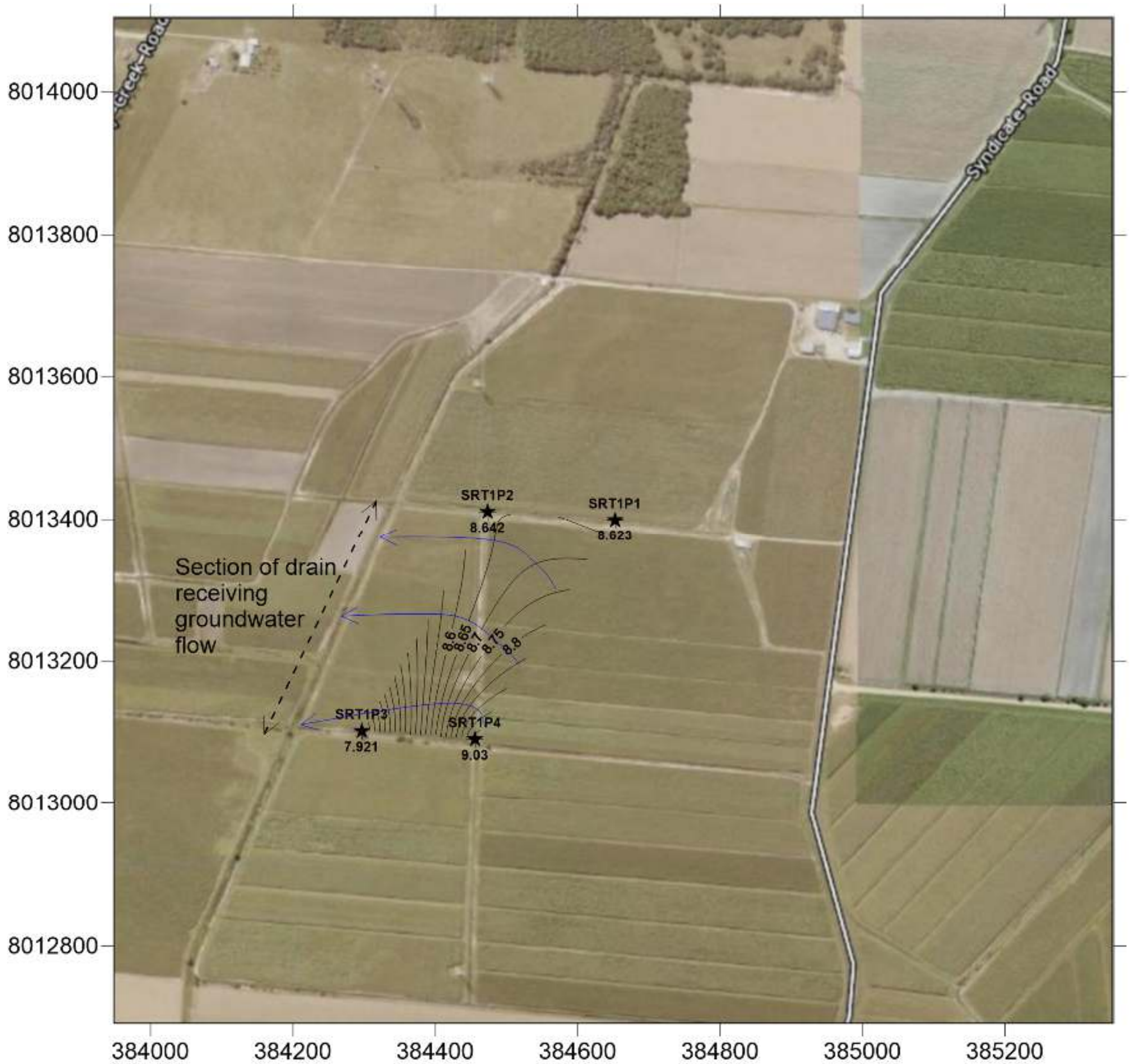
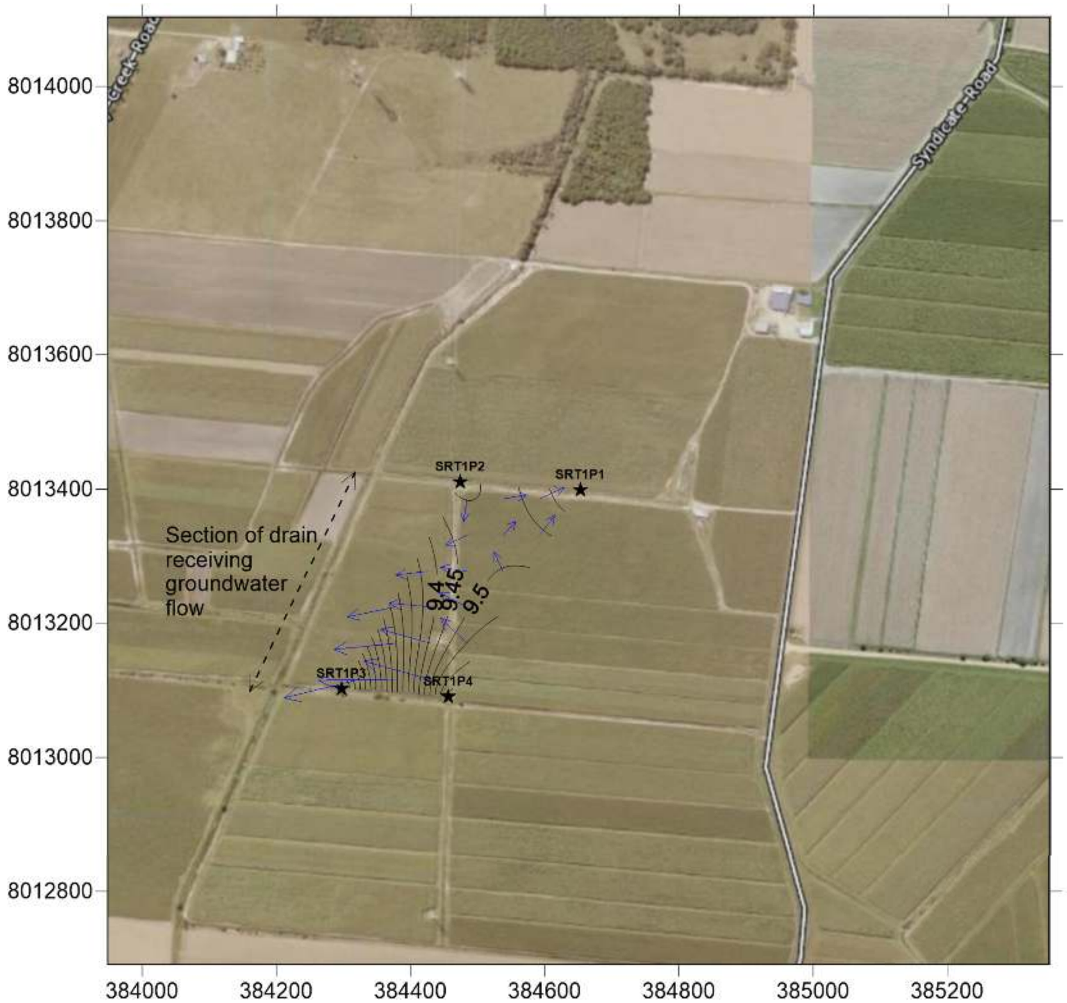


Figure 6: Syndicate Road potentiometric surface contours and groundwater flow directions 20th January 2020



Blue arrows show principal groundwater flow directions

Figure 7: Syndicate Road potentiometric surface contours and groundwater flow directions 28 September 2020



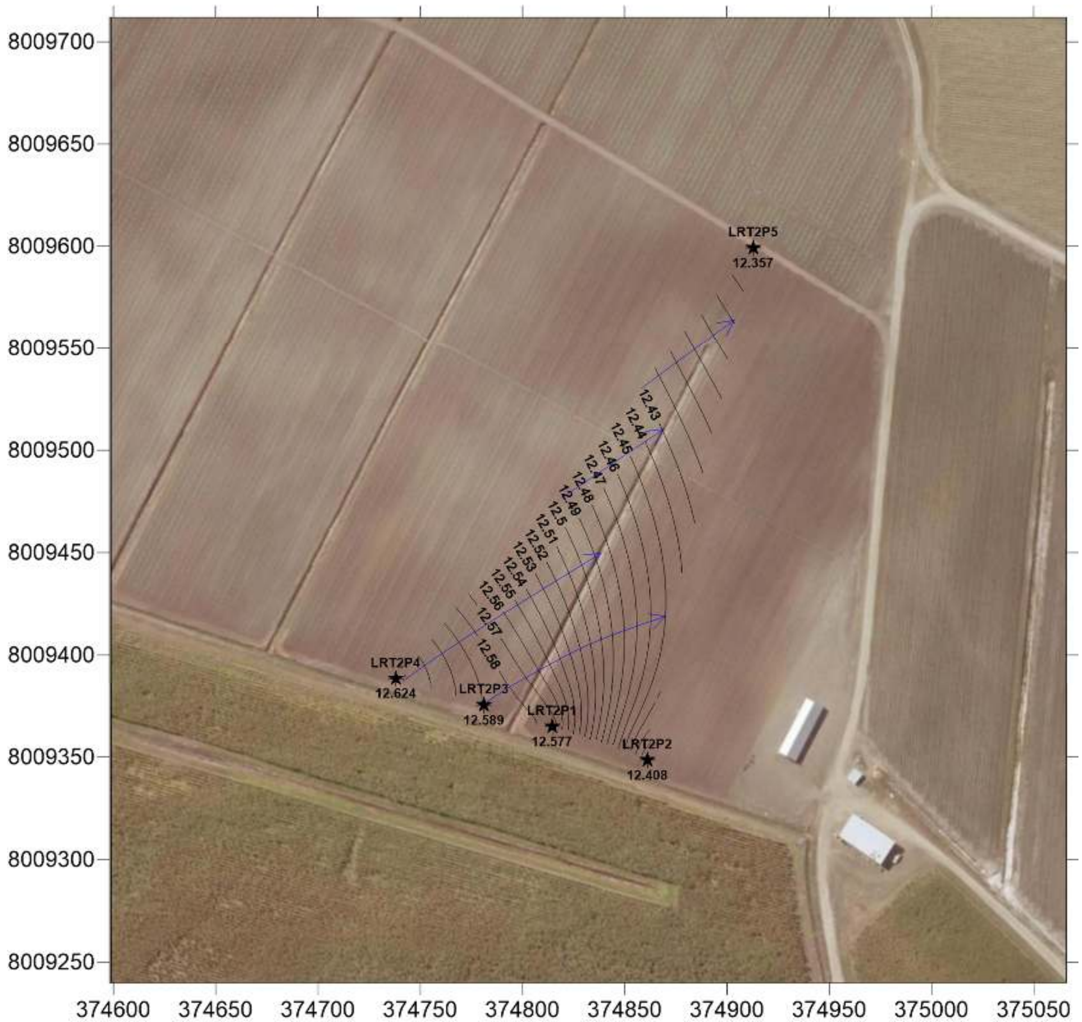
Syndicate Rd potsurf 19 Jan 2021 Highest water level conditions

Figure 8: Syndicate Road potentiometric surface contours and groundwater flow directions 19th January 2021

Figures 6, 7 and 8 show that groundwater flow is from east to west for all groundwater level conditions (lowest to highest). Groundwater flow will express in the drain to the west of the Syndicate Road piezometers if the elevation of the depth of incision of the western drain is higher than the water table elevation, under all groundwater level scenarios.

Leichhardt Road

Figures 9 and 10 show groundwater flow directions for 28th September 2020 (reported previously) and 19th January 2021 (the highest groundwater level condition). Note that it is not possible to assess groundwater flow directions for 20th January 2020 as LRT2 P5 did not exist at that time, and all the other piezometers are in a straight line.



Blue arrows show principal groundwater flow directions

Figure 9: Leichhardt Road potentiometric surface contours and groundwater flow directions
28 September 2020

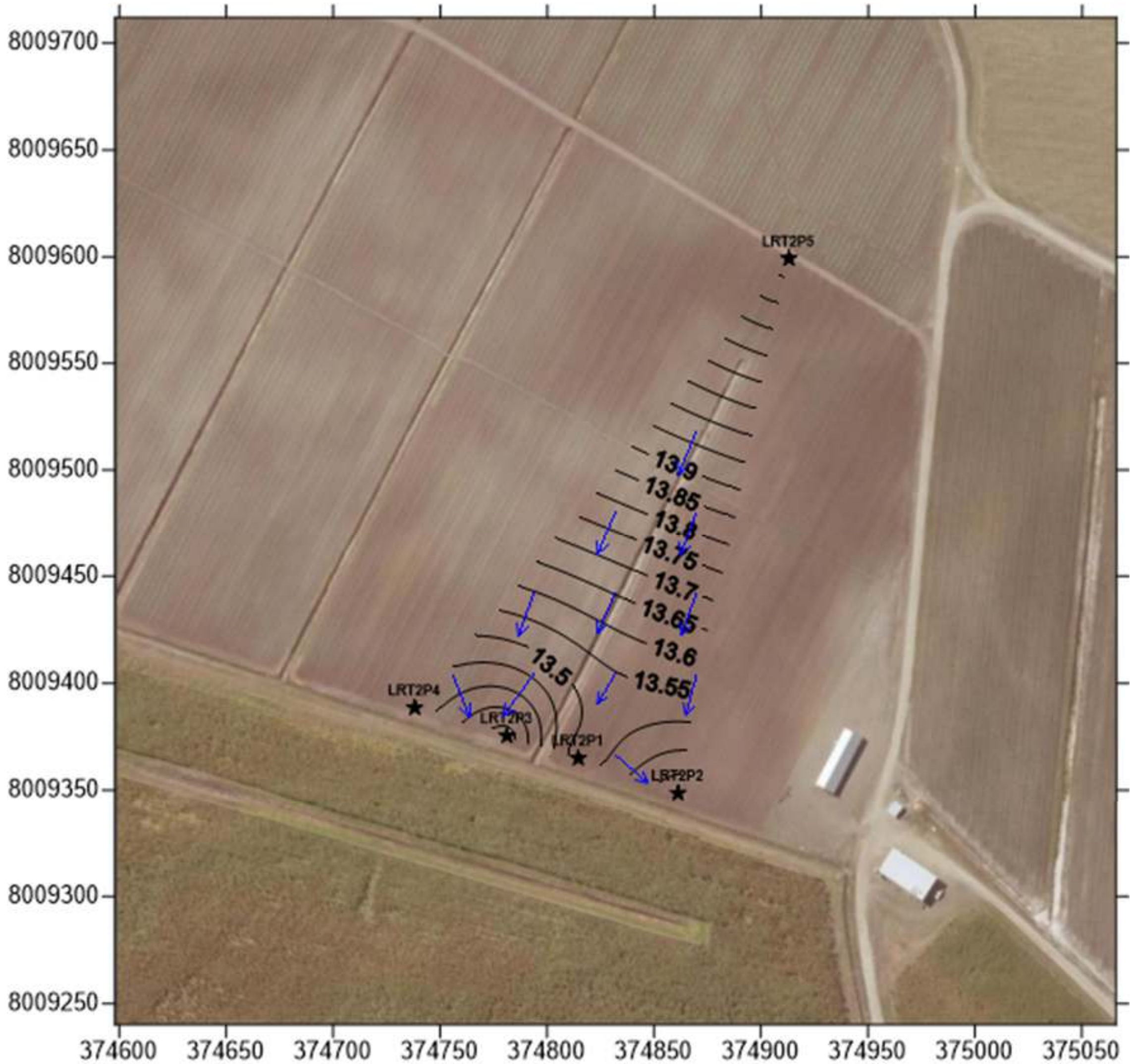


Figure 10: Leichhardt Road potentiometric surface contours and groundwater flow directions
19th January 2021

Figure 9 shows that groundwater flow was from south west to north east; i.e. away from the farm drain adjacent to LRT2P4 to LRT2P2. It is assessed that groundwater flow will express in the lateral drain that runs at 90° to the farm drain adjacent to LRT2P4 to LRT2P2, if the elevation of the depth of incision of the lateral drain is higher than the water table elevation.

Figure 10 shows that the predominant groundwater flow direction is from the north east towards the south west. This represents a reversal of groundwater flow towards the drain adjacent to the original piezometers (LRT2P1 to LRT2P4). The aquifer sequence beneath the cane field between the drain adjacent to the original piezometers and LRT2P5) became saturated during the sustained rainfall that occurred in the area in early January 2021.

The drain adjacent to the original piezometers reverted from being a losing stream to a gaining stream because of the early January 2021 rainfall.

3.3 Water table gradient

Syndicate Road

The gradient of the water table was assessed by examining the potentiometric surface contours and the formula:

Water table gradient (i) = (water level elevation at highest section of the potentiometric surface contours - water level elevation at lowest section of the potentiometric surface contours) / distance between these points

In the case of Syndicate Road, the groundwater gradients that apply are:

- For 28th September 2020 0.00242
- For 19th January 2021 0.00479

Contrary to the previously reported conclusion that there was “no wholesale change in water table gradient with changes in seasonal groundwater levels”, the intensive rainfall event of early January 2021 steepened the groundwater gradient at the Syndicate Road site.

Leichhardt Road

The same techniques as described above were used to assess the median water table gradient at Leichhardt Road.

- For 28th September 2020 0.00242 (from south west to north east)
- For 19th January 2021 0.00506 (from north east to south west)

It is also evident that rainfall event of early January 2021 steepened the groundwater gradient at the Leichhardt Road site.

3.4 Groundwater flow volume

The high hydraulic conductivity values calculated for T1P1 and T1P4 are reflective of the fact that both of these piezometers are screened in sand. T1P2 and T1P3 are screened in clayey sediments. Owing to the wide range of hydraulic conductivity values it is considered reasonable to adopt a median hydraulic conductivity value of 6.32 m/d for the subsurface sequence at Syndicate Road.

The higher hydraulic conductivity values calculated for T2P3 at the Leichhardt Road site, and T1P4 at the Syndicate Road site, are reflective of the fact that both of these piezometers are screened in sand. The remaining piezometers at each site are screened in clayey sediments.

Overall, the hydraulic conductivity of the subsurface material at Leichhardt Road is lower than that at Syndicate Road. It is considered reasonable to adopt a median hydraulic conductivity value of 1.02 m/d for the subsurface sequence at Leichhardt Road.

The volume of groundwater flow to the receiving site is assessed using Darcy's Equation:

$$Q = KiA \quad (m^3/day)$$

where: K = Median coefficient of hydraulic conductivity
i = Median water table gradient
A = cross sectional area[2] of aquifer

Three key assumptions are inherent when assessing groundwater flow volume through porous media:

1. There is hydraulic continuity through the aquifer being assessed;

2. Adoption of the median hydraulic conductivity is reasonable; and

3. There is a mechanism for discharge at the down-gradient end of the potentiometric surface.

Syndicate Road

By applying Darcy's Equation, a groundwater flow volume of about 12900 L/d was calculated to arrive in the western drain on September 28th 2020.

A volume of 34200 L/d was calculated to arrive in the western drain on 19th January 2021, owing to a greater saturated thickness of aquifer and increased groundwater gradient.

Leichhardt Road

By applying Darcy's Equation, a groundwater flow volume of about 600 L/d was calculated to arrive in the central drain on September 28th 2020.

A volume of 5800 L/d was calculated to arrive in the central drain on 19th January 2021, owing to a greater saturated thickness of aquifer and increased groundwater gradient. It is reiterated that the groundwater flow direction on 19th January 2021 was the opposite of that on 28th September 2020. Regardless of this, the central drain is still considered to be a groundwater flow interception feature.

3.5 Analytes in groundwater

The methodology for assessing analyte loads arriving at groundwater discharge zones was described in RLA, November 2020.

[2] Cross sectional areas based on the average saturated thickness of aquifer and the length of the discharge zone.

As there is now a considerable period of groundwater level and analyte data it is considered prudent to examine the mechanism of analyte movement in the aquifer sequence. To this end the measured concentration of Dissolved Inorganic Nitrogen (DIN) was plotted against depth to groundwater for all the project piezometers. DIN was selected as the data for this analyte are the most complete. Figures 11 to 19 show these plots.

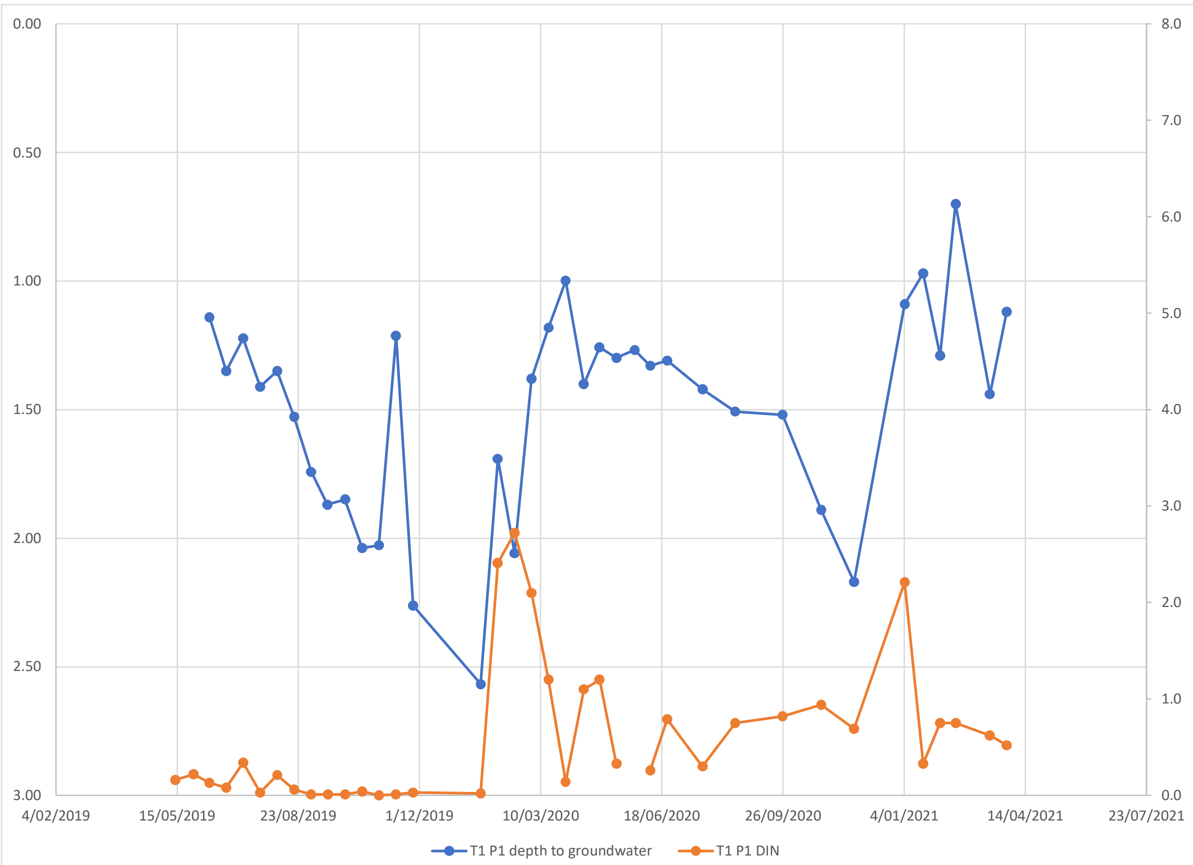


Figure 11: Plot of Depth to groundwater versus DIN Syndicate Road T1 P1
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

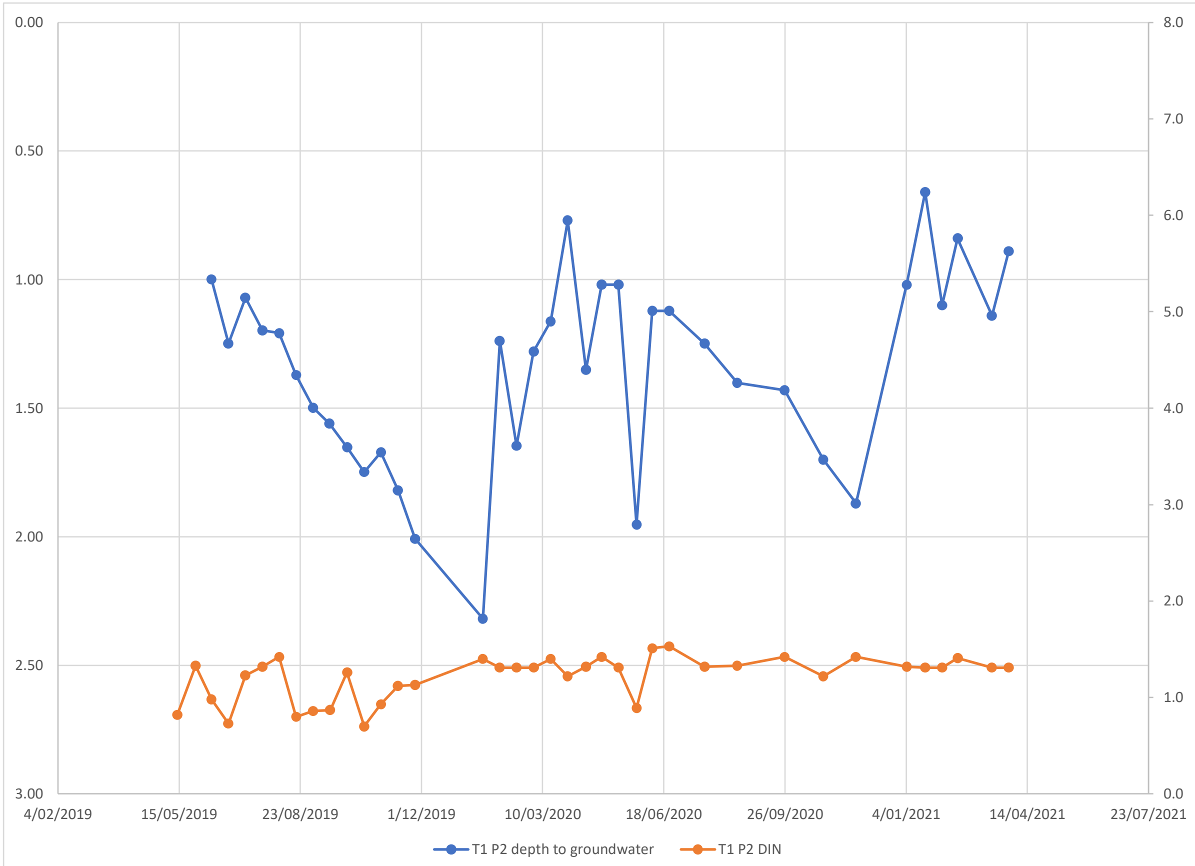


Figure 12: Plot of Depth to groundwater versus DIN Syndicate Road T1 P2
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

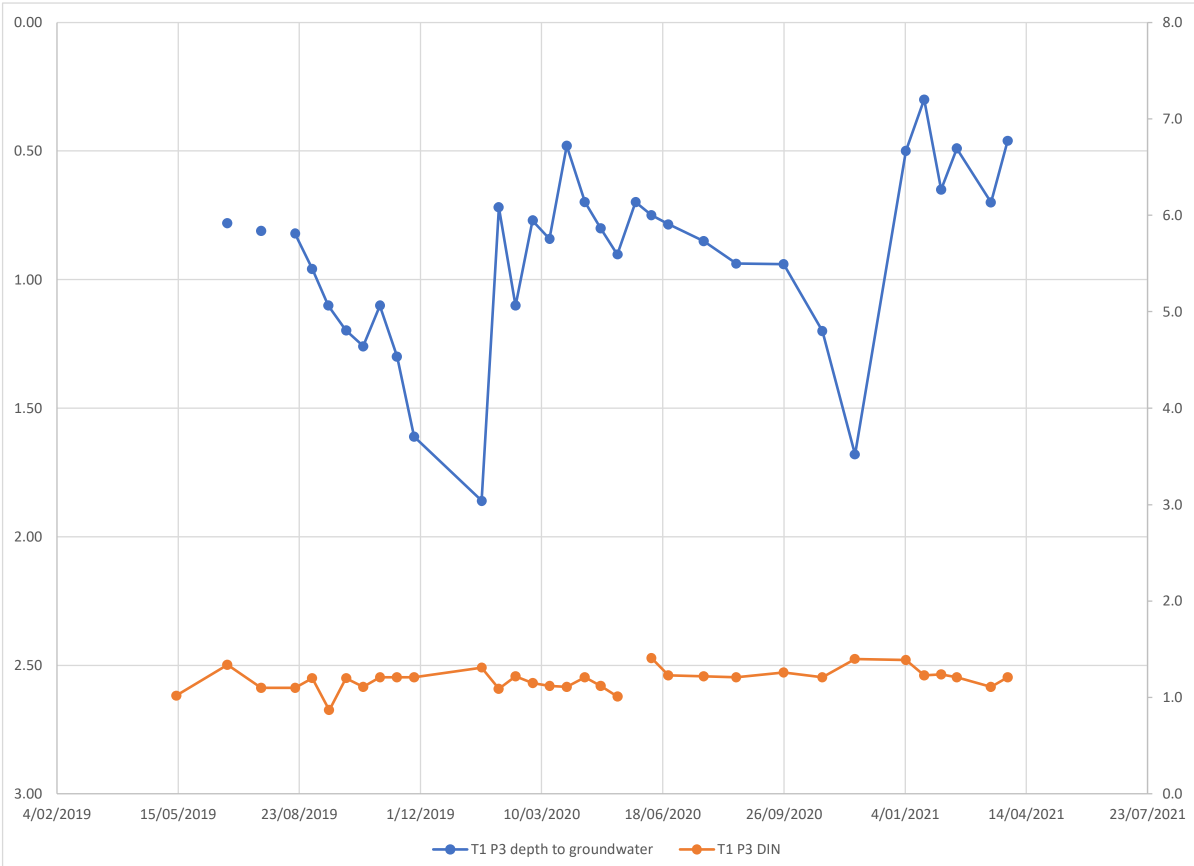


Figure 13: Plot of Depth to groundwater versus DIN Syndicate Road T1 P3
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

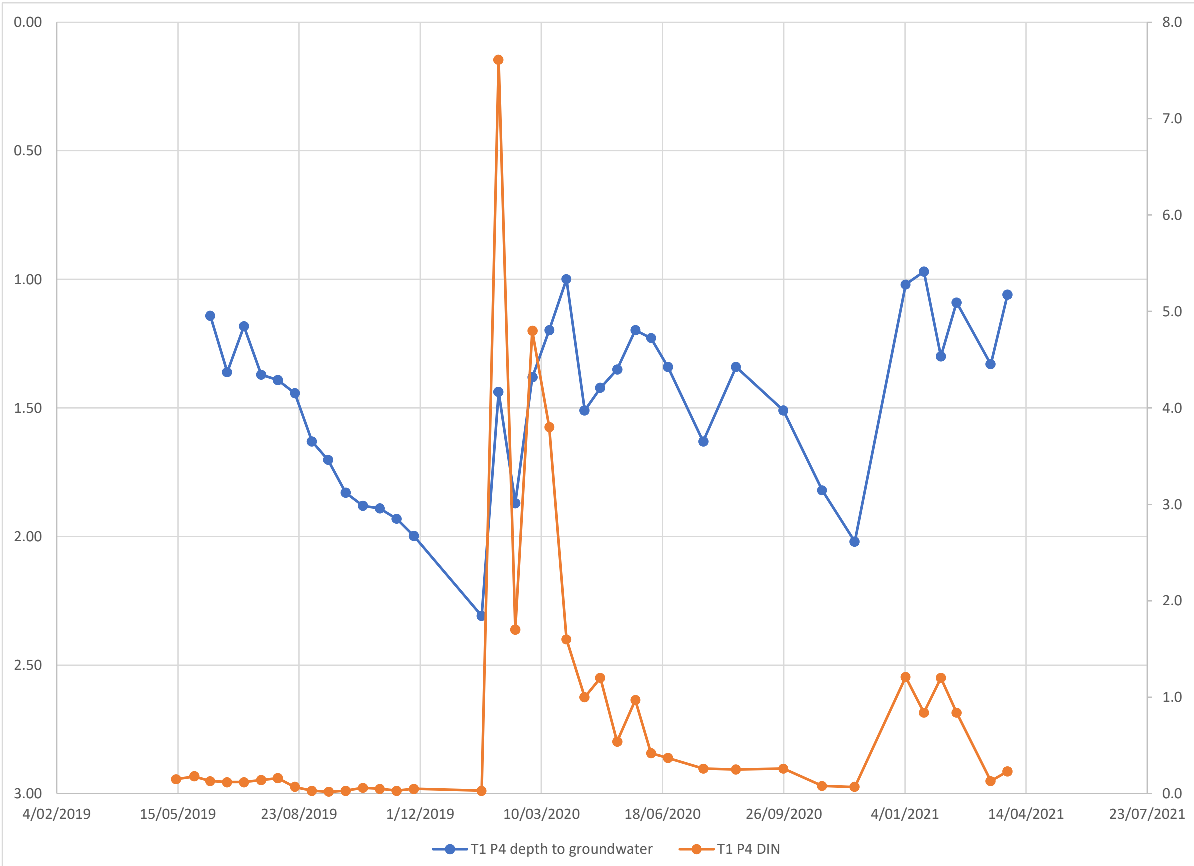


Figure 14: Plot of Depth to groundwater versus DIN Syndicate Road T1 P4
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

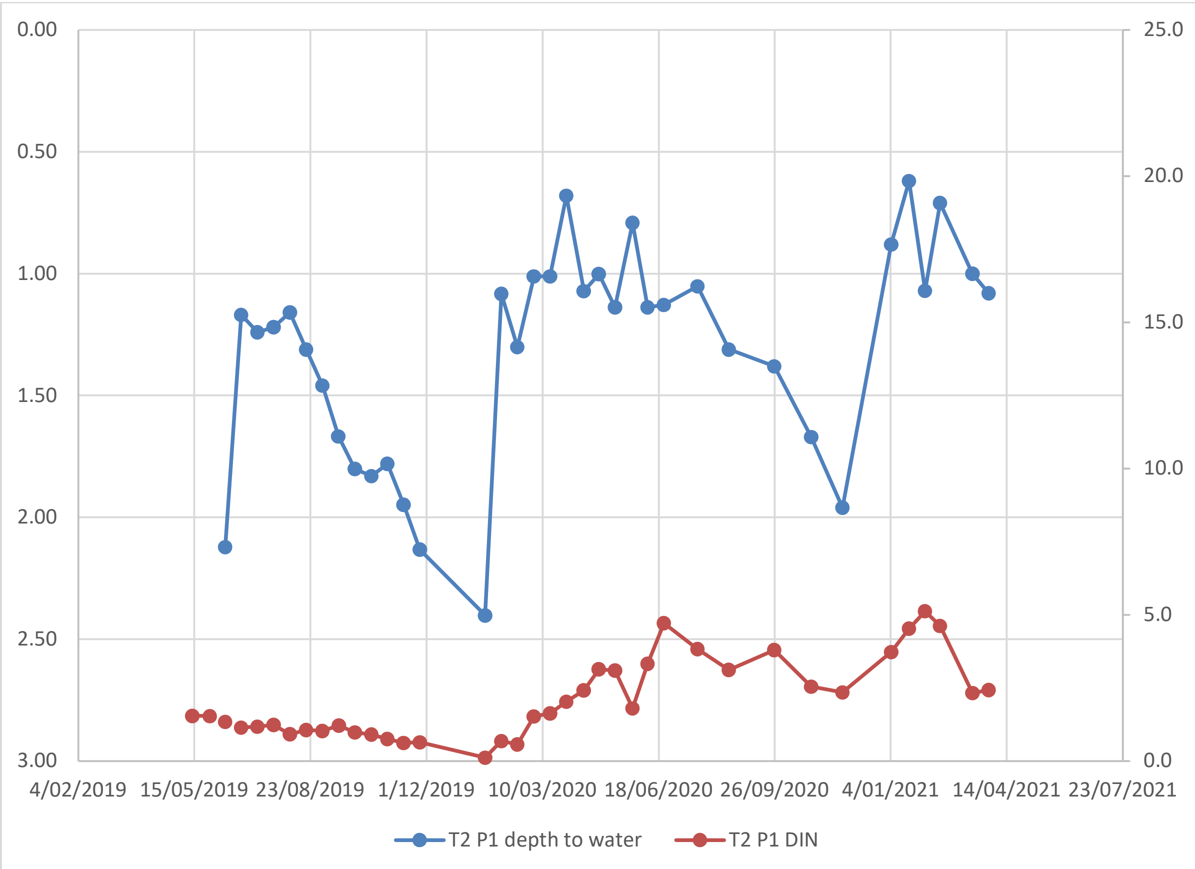


Figure 15: Plot of Depth to groundwater versus DIN Leichhardt Road Leichhardt Road T2 P1
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

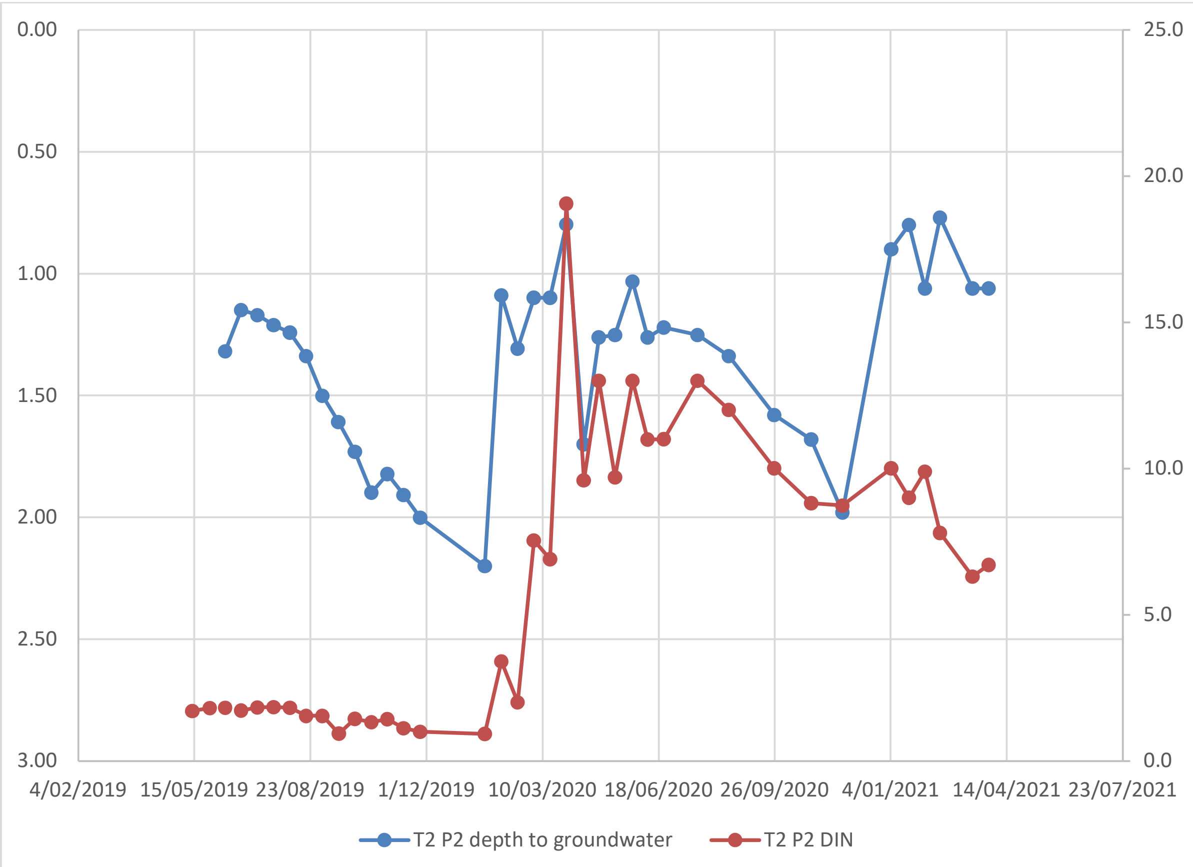


Figure 16: Plot of Depth to groundwater versus DIN Leichhardt Road T2 P2
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

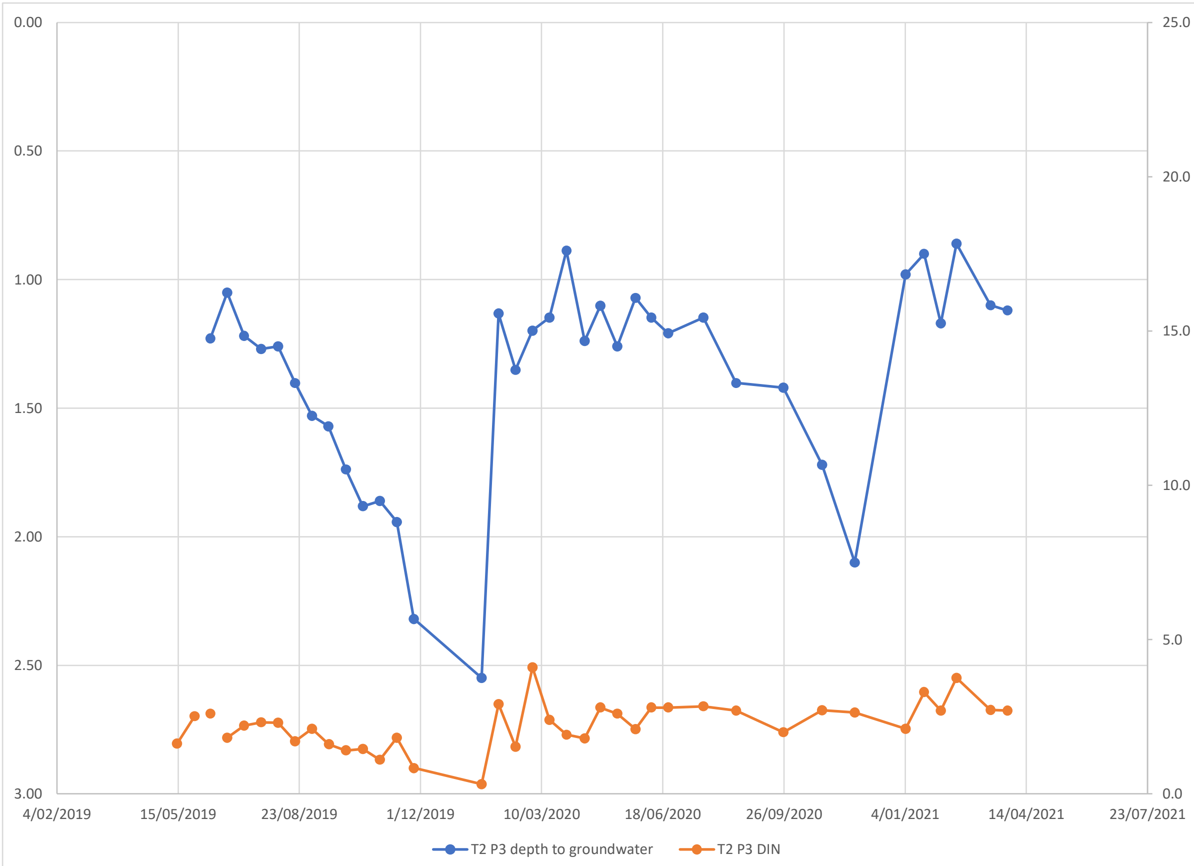


Figure 17: Plot of Depth to groundwater versus DIN Leichhardt Road T2 P3
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

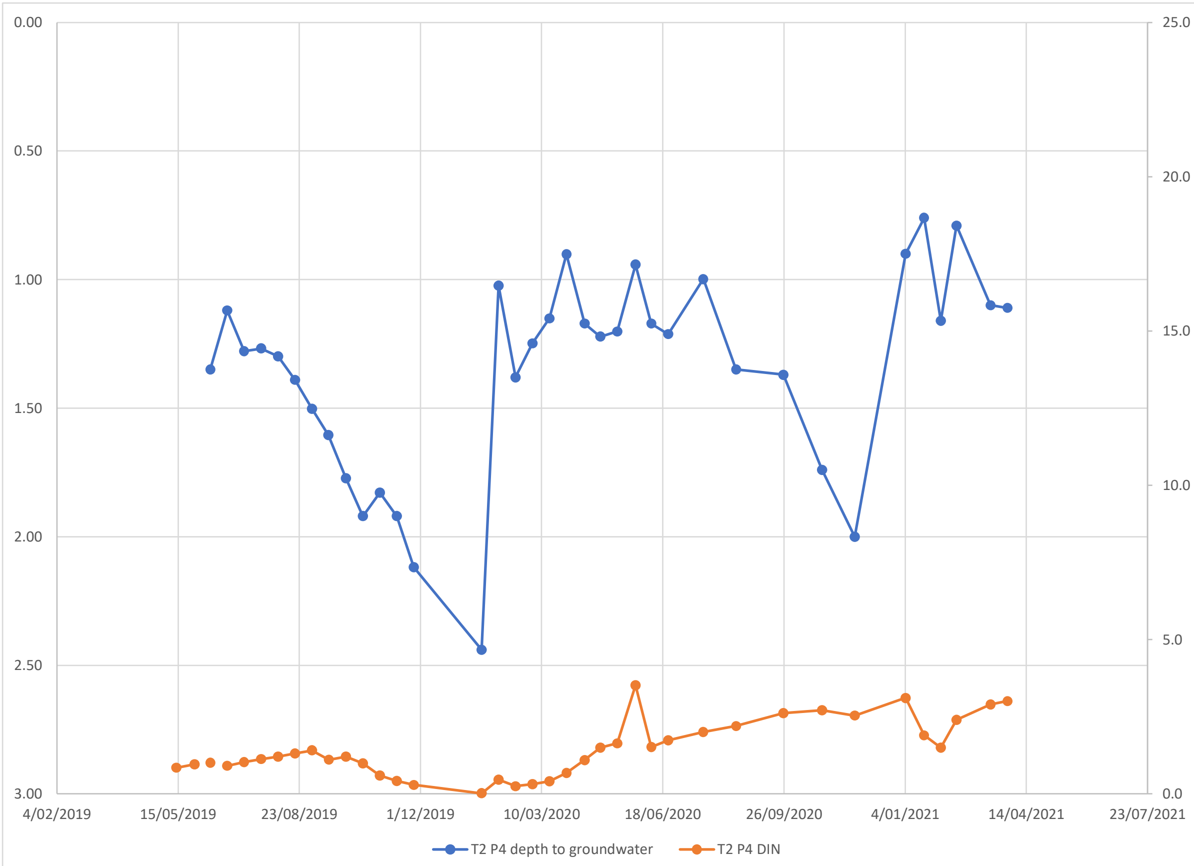


Figure 18: Plot of Depth to groundwater versus DIN Leichhardt Road T2 P4
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

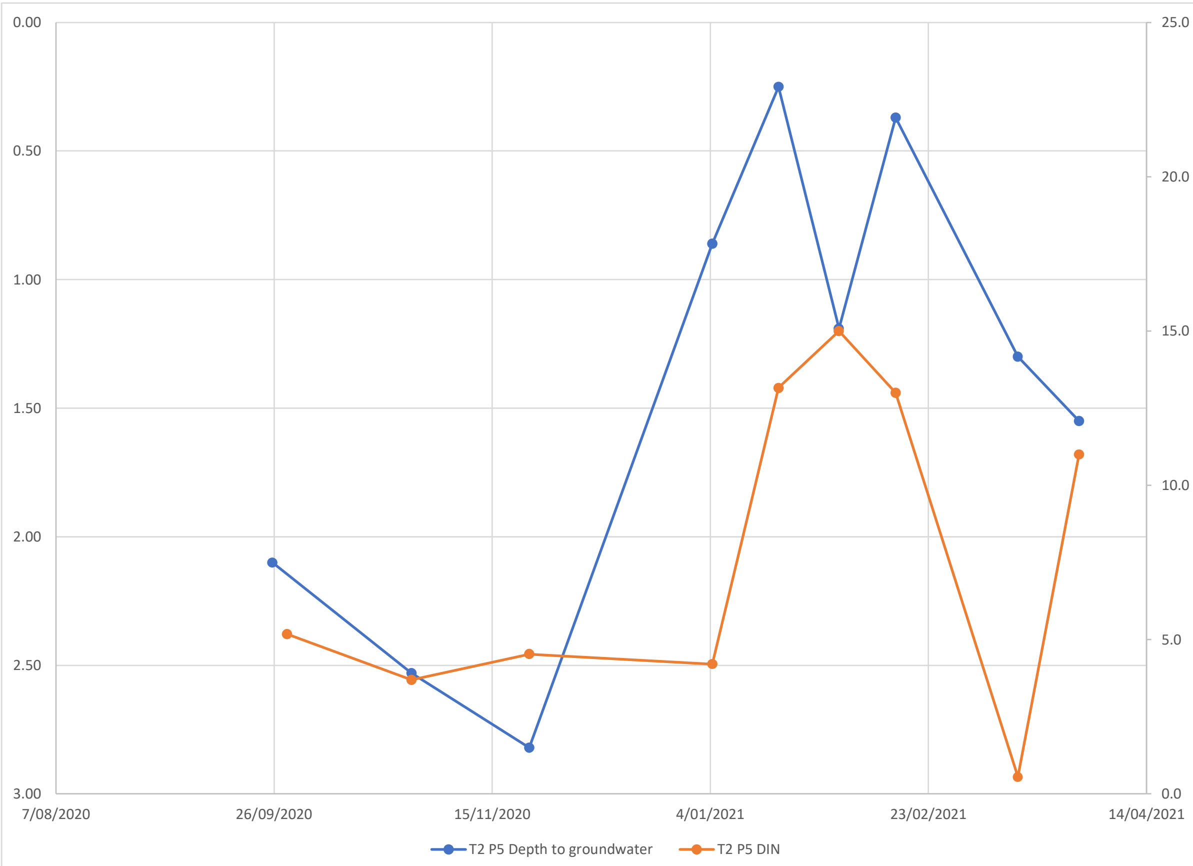


Figure 19: Plot of Depth to groundwater versus DIN Leichhardt Road T2 P5
Left hand vertical axis is depth to groundwater below the measurement point
Right hand vertical axis is concentration of DIN in mg/L

Figures 11 to 19 show that:

- There is considerable variation in the measured concentrations of DIN in each piezometer across each of the sites; and
- Intensive rainfall, such as in early January 2021, mobilises DIN in the subsurface.

These observations are probably as relevant to the other measured analytes at the project sites.

4.0 ACHIEVEMENT OF OBJECTIVES

As previously stated, the objectives of this report were to:

- Provide guidance to the WTMIP team on the direction of groundwater flow at the two sites that would lead to a better understanding of the dissolved inorganic nitrogen (DIN) under different land use practices; and
- Determine whether further groundwater testing using the piezometers was needed to add to that understanding.

It is considered that the first objective has been achieved.

Regarding the second objective, the author considers that the suite of data that has been gathered by the WTMIP team is fit for its purpose. Of course, any groundwater evaluation benefits from having as many piezometers as possible. However, given the size of each investigation site, there is an adequate number of piezometers coupled with regular groundwater measurements to permit a reasonable understanding of the hydrogeological regime at each site. The author does not see the need for further groundwater testing beyond what is already carried out.

Therefore, it is considered that the second objective has also been achieved.

5.0 KEY FINDINGS

5.1 Hydrogeological regime

The key hydrogeological regime findings of this study are:

1. Groundwater levels rise and fall very rapidly in response to incident rainfall. This is typical of relatively high permeability shallow aquifers in Queensland's Wet Tropics;

2. As a consequence, groundwater gradients steepen or become shallower depending on prevailing groundwater levels;

3. As groundwater gradients are a key driver of groundwater flow through any aquifer, the volume of groundwater that enters (or in some cases, leaves) the drains that are present at the project sites varies seasonally.

5.2 Dissolved Inorganic Nitrogen

The key findings of this segment of the study were provided by Dr John Armour:

1. DIN concentrations varied at both sites and ranged to as high as 25 mg/L. The changes in concentrations are assumed to be the result of groundwater flow and direction as well as fertiliser nitrogen management of paddocks. Recent research in the Johnstone catchment and other local catchments has clearly shown the impact of nitrogen management on concentrations of DIN in drainage moving below the root zone (e.g. Armour *et al.* 2013)[3]. In addition, the Local Scale Monitoring program of the WTMIP reported steady increases in DIN concentrations in streams (e.g. Liverpool Creek) as water levels receded post-flow event, which was attributed to discharge of groundwater into the streams (*pers. comm.* Alicia Buckle, WTMIP Water Quality Project Officer (Leader), email dated 25 June 2021).

2. The data from all these projects show the importance of paddock management to minimise the loss of DIN from the root zone before it is subject to uncontrolled movement.

<u>Rob Lait and Associates Pty Ltd</u>

<u>ROB LAIT</u>
Principal Hydrogeologist

[3] Armour, J.D. Nelson, P.N., Daniells, J.W., Rasiah, V. and Inman-Bamber, N.G. (2013). Nitrogen leaching from the root zone of sugarcane and bananas in the humid tropics of Australia. Agriculture, Ecosystems & Environment, 180, pp. 68-78.

LIMITATIONS OF REPORT

Rob Lait and Associates Pty Ltd (RLA) has prepared this report for the use of WTMIP Natural Resource Management based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

This study was undertaken between 10th and 12th May 2021 using data obtained from WTMIP, and is based on the conditions encountered and the information available at the time of preparation of the report. RLA disclaims responsibility for any changes that may occur after this time.

The methodology adopted and sources of information used by RLA are outlined in this report. RLA has made no independent verification of this information beyond the agreed scope of works and RLA assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to RLA was false.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex.

Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, RLA must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.