

JBS Townsville

Environmental Evaluation of Wastewater Irrigation

Response to a Request - DES CA4544; 101/0008424

Requirement 5

Ver 2.1



Prepared for

JBS Australia

By

Bio-Track Pty Ltd

July 31, 2019

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1 INTRODUCTION

Bio-Track Pty Ltd has been commissioned by JBS Australia to provide a response to a request for information from DES, requirement #5. The DES RFI is dated 25 September 2018, Reference, CA45444 101/0088424. Requirement 5 is copied below. JBS Townsville has undertaken monthly sampling of groundwater from four permanent monitoring bores (PMB) and six temporary monitoring bores (TMB). JBS staff have made measurements of groundwater levels when sampling. Chemical analysis of water samples has been undertaken by TropWater, Townsville. This report is based upon information provided by JBS. This report is intended to be used by JBS Australia and Queensland government agencies. It is not intended for third party use or distribution.

Requirement 5

By 1 August 2019, you must provide a written report, prepared by an appropriately qualified person, to the administering authority:

- (a) which describes how Requirements 2, 3 and 4 have been carried out; and*
- (b) which utilises the results of groundwater monitoring to provide an assessment of any impact(s) on groundwater from the activity; and*
- (c) which describes any source(s) of groundwater contamination and how groundwater contamination may have been caused; and*
- (d) which describes the extent of any contamination of groundwater; and*
- (e) which provides an evaluation of reasonable and practicable remediation measures of any identified impact to environmental values; and*
- (f) which recommends the most appropriate remediation measure and provides a work program to implement the recommendations with estimated timeframes*

Requirements 2, 3 and 4 are listed below.

Requirement 2

By 29 June 2018 an appropriately qualified person must investigate, describe and report on the groundwater system at, and in the vicinity of, the premises, to characterise the groundwater potentially affected by the activity. The report must include at least descriptions of:

- (a) The hydrogeology in and around the premises; and*
- (b) Any perching or confining features; and*
- (c) Depths to groundwater and groundwater elevation in metres Australian Height Datum (AHD); and*
- (d) Gradients and flow directions; and*
- (e) Hydraulic properties of the host soils and lithology; and*
- (f) Potential interaction with surface waters; and*
- (g) Identification of potential groundwater dependent ecosystems and how groundwater interacts with them.*

Requirement 3

By 29 June 2018 an appropriately qualified person must design and implement a groundwater monitoring network that ensures:

- (a) Bores are constructed in accordance with the "Minimum Construction Requirements For Water Bores in Australia" (Third edition) - National Uniform Drillers Licensing Committee 2011 ; and*
- (b) a sufficient number of representative groundwater samples can be collected from the uppermost aquifer(s) and any deeper aquifer(s) likely to be impacted by the activity; and*
- (c) a sufficient number of representative groundwater samples can be collected from hydraulically upgradient or background bore(s) that have not been affected by any release of contaminants from the activity to groundwater; and*
- (d) a sufficient number of representative groundwater samples can be collected from hydraulically down gradient or impacted bore(s) of any potential or actual release of contaminants to groundwater from the activity.*

Requirement 4

By 29 June 2018 using the groundwater monitoring network required by requirement 3 you must commence monitoring and keep records of groundwater quality for the relevant monitoring bores and maintain the groundwater monitoring program using an appropriately qualified person, or person(s) trained and supervised by an appropriately qualified person. All determinations of groundwater quality must be:

- (a) conducted for the water quality characteristics and at the minimum frequency stated in Table 1;*
- (b) carried out with sufficient regularity and temporal replication to make valid conclusions about the presence or absence of contamination or other impact;*
- (c) made in accordance with the best practice methods prescribed in the latest edition of the ASINZS 5667.11: 1998 (R2016) Water quality - Sampling - Guidance on sampling of groundwaters.*

EE-Table 1 Groundwater Quality Characteristics to be monitored and monitoring frequency

Quality characteristic	Units	Monitoring frequency
pH	pH Unit	Monthly (in situ)
Electrical Conductivity	µS/cm	Monthly (in situ)
Ammonia as N	mg/L	Monthly
Nitrite and Nitrate as N	mg/L	Monthly
Total Nitrogen as N	mg/L	Monthly
Total Phosphorus as P	mg/L	Monthly

2 Requirement 5 (a)

Reports describing the requirements 2,3 and 4 have been previously submitted to JBS. These reports have been provided to DES and it is assumed the reader will have access to these documents. This information has not been duplicated in this report.

Groundwater monitoring has continued and this forms the basis of new data that is addressed in this report.

3 Requirement 5 (b & c)

- (b) **“Provide an assessment of any impact(s) on groundwater from the activity ; and**
- (c) **which describes any source(s) of groundwater contamination and how groundwater contamination may have been caused;”**

List items b) and c) are addressed in this section.

For the purposes of this report “the activity” relates to irrigation of effluent from the treatment lagoon to the land. This activity is confined to JBS property at Townsville.

3.1 Background & Methods

There are four permanent monitoring bores (PMB) and six temporary monitoring bores (TMB) that have been sampled and analysed from May 2018 to June 2019. Summary tables of the analytical data are provided in Table 1. Copies of the analytical test certificates are provided in Appendix 1.

The four permanent monitoring bores extend to a depth of 30 metres and have the inlet screen for the depth range 29 to 30 (approximately) metres. The inlet screen depth was determined by JBS staff in 2018 using a bore hole camera. Details for the installation date, bore logs and construction are unknown.

The location of the groundwater monitoring bores is provided in Figure 1 and Appendix 3.

Sampling of the groundwater monitoring bores was undertaken by JBS field staff. Samples were submitted to the Tropwater laboratory in Townsville for chemical analysis. Groundwater level measurements were also undertaken by JBS staff. The groundwater level data is provided in Table 1.

A flood occurred during the period December 2018 to February 2019. Flood levels are reported to have exceeded a 1:100 year flood level. Groundwater samples and measurements were suspended for February and March 2019 due to lack of safe access.

TMB1 is dry most of the time and had one measurement event. The remaining bores all intersect with the groundwater for all of the sampling events. The summer rain 2018-2019 was a major flood event. Climatic conditions during this period are not typical of the site.

Piezo locations are permanent monitoring bore locations (PMB)

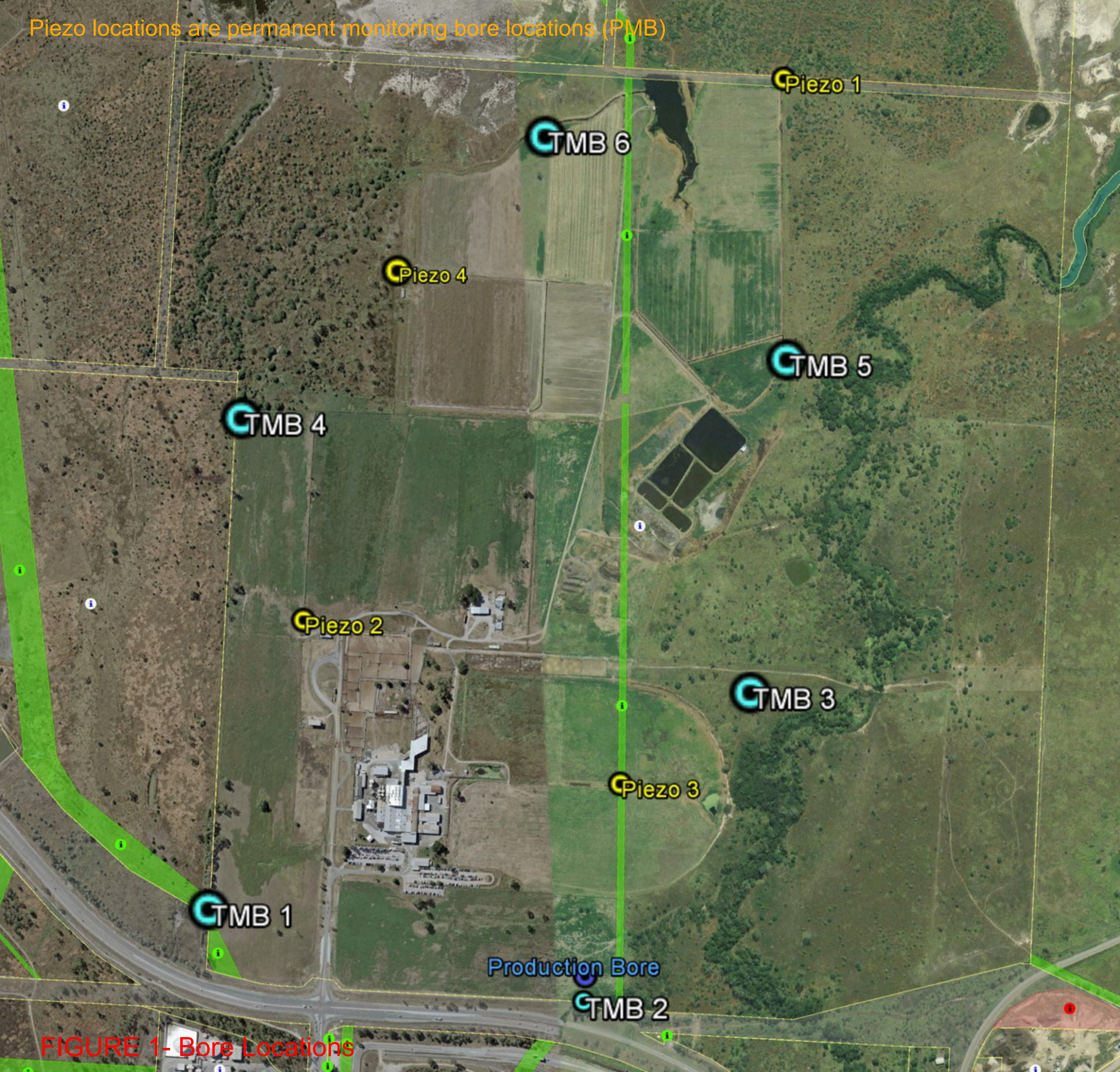


FIGURE 1- Bore Locations

	Analysis	G.W.L	Ammonia	Nitrite	Nitrate	Total Nitrogen	Filterable Reactive P.	Total P.
	Date	m AHD	µg N/L	µg N/L	µg N/L	µg N/L	µg P/L	µg P/L
TMB2	10/07/18		23	44	16	1140	634	1579
	9/08/18	5	50	2	5	369	439	696
	5/09/18	4.9	28	4	65	775	1,072	1,500
	4/10/18	4.64	37	6	43	1,032	893	1,515
	16/11/18	4.92	142	5	71	1,821	1,517	2,154
	11/12/18	4.71	28	1,016	14,396	15,571	419	900
	9/01/19	5.12	121	404	59,497	102,981	366	489
	4/04/19	5.94	43	182	27,974	28,502	694	833
	27/05/19	5.41	150	859	19398	20379	649	887
	18/06/19	5.03	20	392	4,493	7,192	591	850
	28/06/19		74	147	3799	7037	404	484
	24/07/19		49	70	917	2391	301	465

TMB3	10/07/18		3	2	8	339	18	126
	7/08/18	3.36	<1	1	3	211	18	82
	5/09/18	3.04	9	2	16	356	93	254
	4/10/18	3.06	3	5	20	307	37	115
	16/11/18	2.94	17	2	6	397	20	100
	11/12/18	2.68	51	10	40	532	18	81
	9/01/19	3.26	5	9	21	417	24	108
	4/04/19	4.13	25	<1	40	141	36	45
	27/05/19	3.93	10	5	15	154	25	49
	18/06/19	3.88	2	4	4	113	47	89
	28/06/19		8	2	4	172	28	58
	24/07/19		5	3	3	210	21	47

TMB4	10/07/18		1	7	47	632	55	165
	7/08/18	2.51	<1	2	10	613	49	164
	5/09/18	2.14	5	3	14	430	59	155
	4/10/18	2.17	2	5	27	495	77	133
	16/11/18	2.09	4	2	276	561	171	272
	9/01/19	2.33	64	188	3,518	6,675	56	346
	4/04/19	3.68	49	24	79	4,709	175	343
	27/05/19	3.05	4	1	365	570	246	341
	18/06/19	2.84	26	<1	6	1,452	66	201
	28/06/19		110	2	2	1185	26	148
	24/07/19		77	6	7	920	19	112

TMB5	10/07/18		2	6	223	648	23	132
	7/08/18	3.26	<1	9	538	936	13	116
	5/09/18	2.7	11	6	909	1,383	47	125
	4/10/18	2.6	4	20	1,029	1,118	62	104
	16/11/18	2.85	11	5	653	1,275	9	78
	11/12/18	2.83	21	7	792	1,300	40	109
	9/01/19	2.57	<1	12	621	1,101	71	98
	4/04/19	3.38	24	20	977	1,279	39	92
	27/05/19	3.71	22	33	795	1113	74	122
	18/06/19	3.64	5	33	1,149	1,228	98	115
	28/06/19		4	4	908	1624	18	63
	24/07/19		7	18	859	1546	43	64

TMB6	10/07/18		8	2	33	438	65	191
	7/08/18	3.22	<1	1	1	393	33	202
	5/09/18	1.46	17	2	15	239	64	141
	4/10/18	1.5	7	5	34	347	72	199
	16/11/18	1.39	3	23	39	256	8	22
	11/12/18	1.77	43	<1	7	247	33	123
	9/01/19	1.62	28	<1	<1	841	60	156
	4/04/19	2.9	158	<1	19	575	44	67
	27/05/19	2.31	82	1	25	461	26	121
	18/06/19	2.27	5	<1	3	182	73	128
	28/06/19		27	2	15	187	39	99
	24/07/19		17	2	3	199	36	94

PMB1	10/07/18		80	2	71	344	25	66
	7/08/18	1.61	28	17	13	157	25	47
	5/09/18	1.17	26	2	36	482	31	71
	4/10/18	1.23	25	5	17	247	17	31
	16/11/18	1.3	37	3	32	376	43	63
	11/12/18	1.29	73	1	30	447	37	80
	9/01/19	1.45	49	1	25	566	34	66
	27/05/19		38	1	52	235	19	28
	18/06/19		23	<1	32	441	49	70
	28/06/19		25	3	16	205	35	38
	24/07/19		29	3	25	176	36	67

PMB2	10/07/18		1	2	43	130	28	39
	7/08/18	4.42	2	1	37	104	26	27
	5/09/18	4.31	6	2	77	492	8	51
	4/10/18	4.21	2	5	41	250	16	35
	16/11/18	4.11	34	2	13	248	23	78
	11/12/18	4.07	6	<1	51	174	22	24
	9/01/19	4.1	1	<1	51	158	16	22
	4/04/19		5	<1	112	164	20	28
	27/05/19		2	1	85	120	18	23
	18/06/19		2	<1	96	99	34	43
	24/07/19		14	2	37	122	10	21

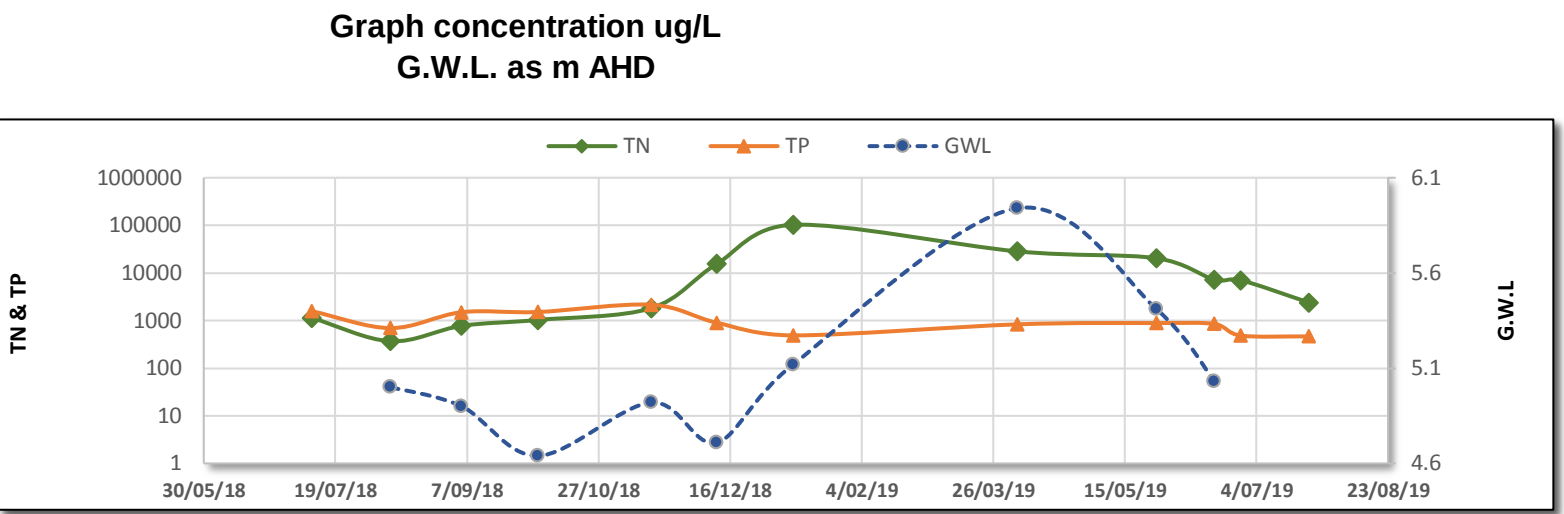
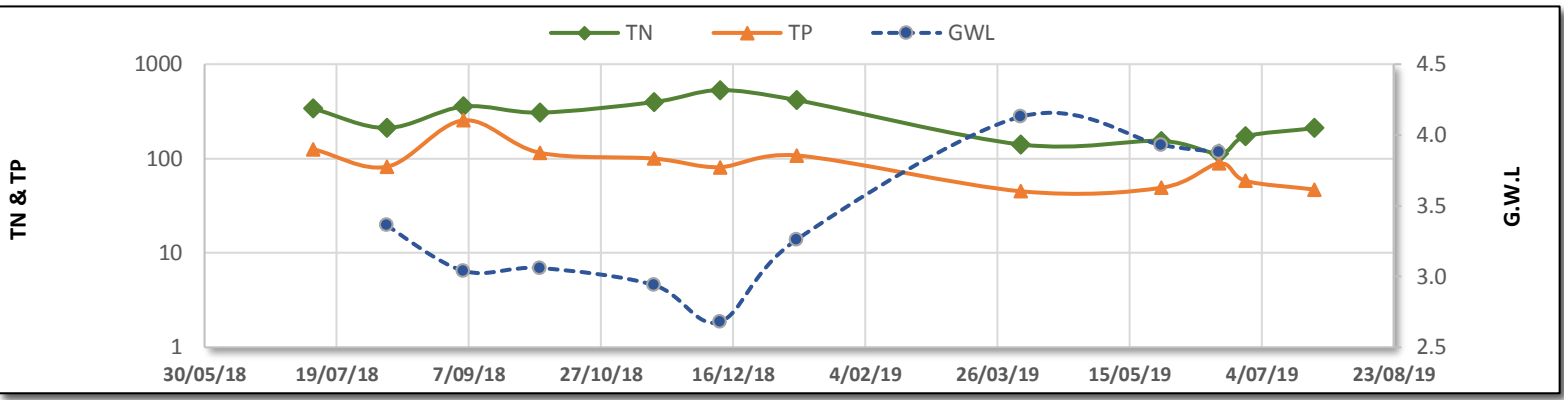
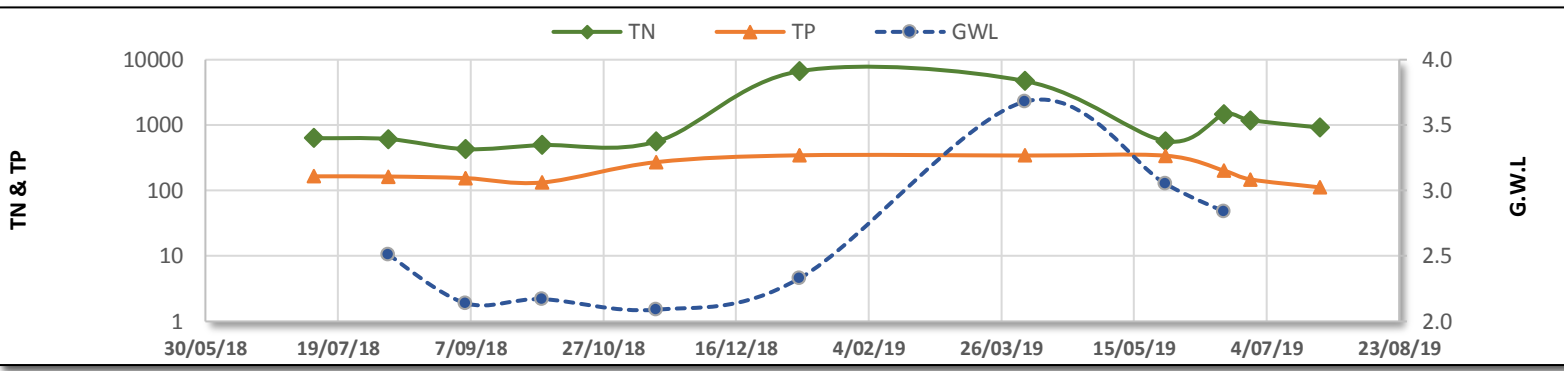
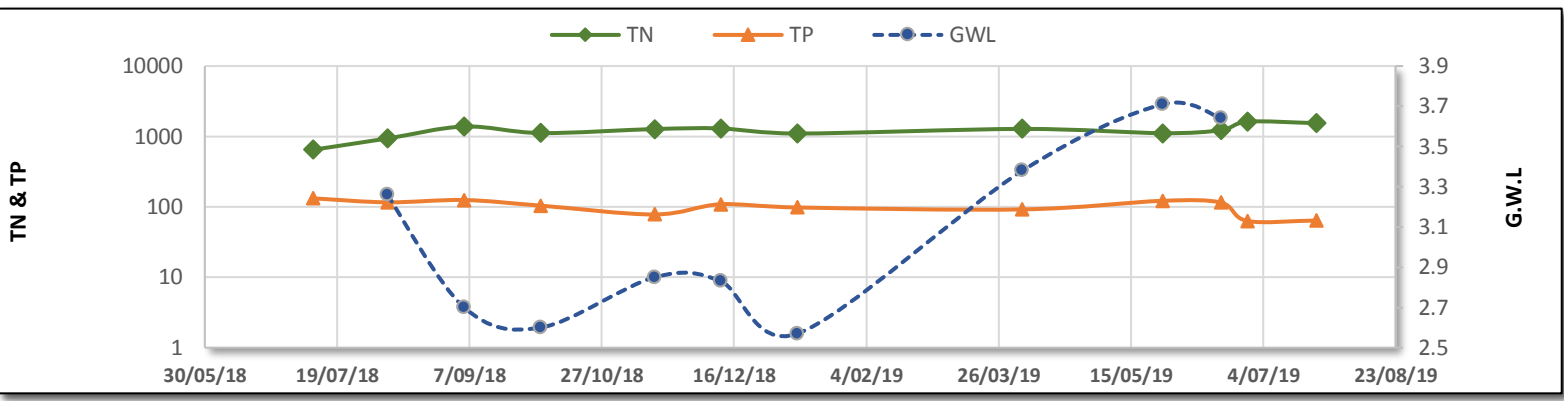
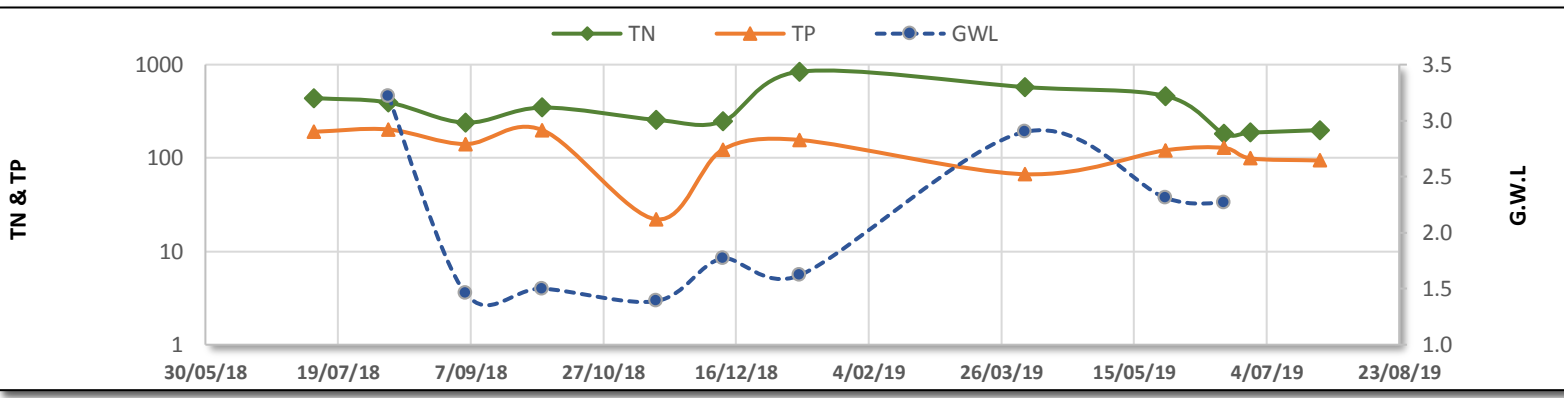
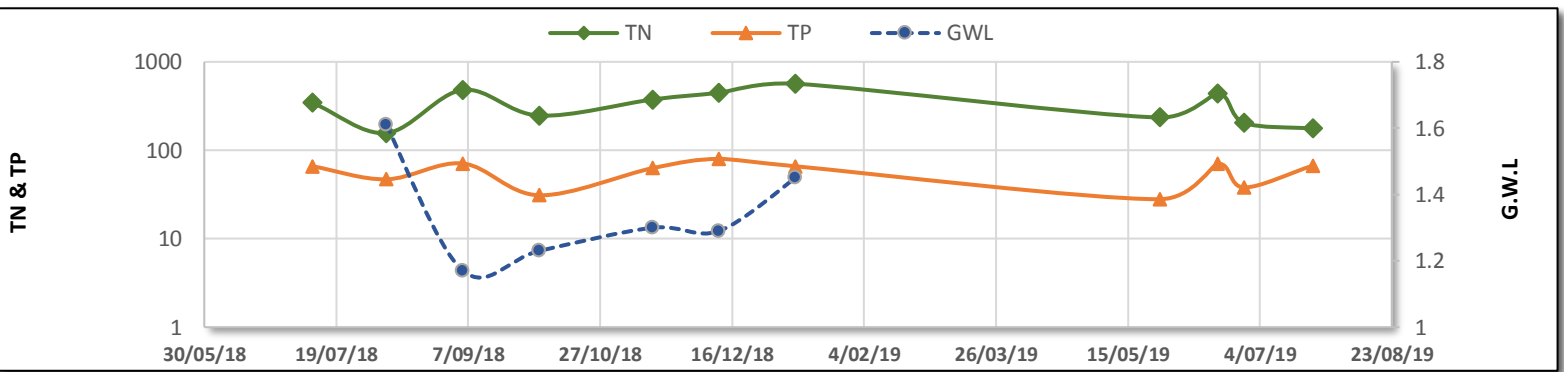
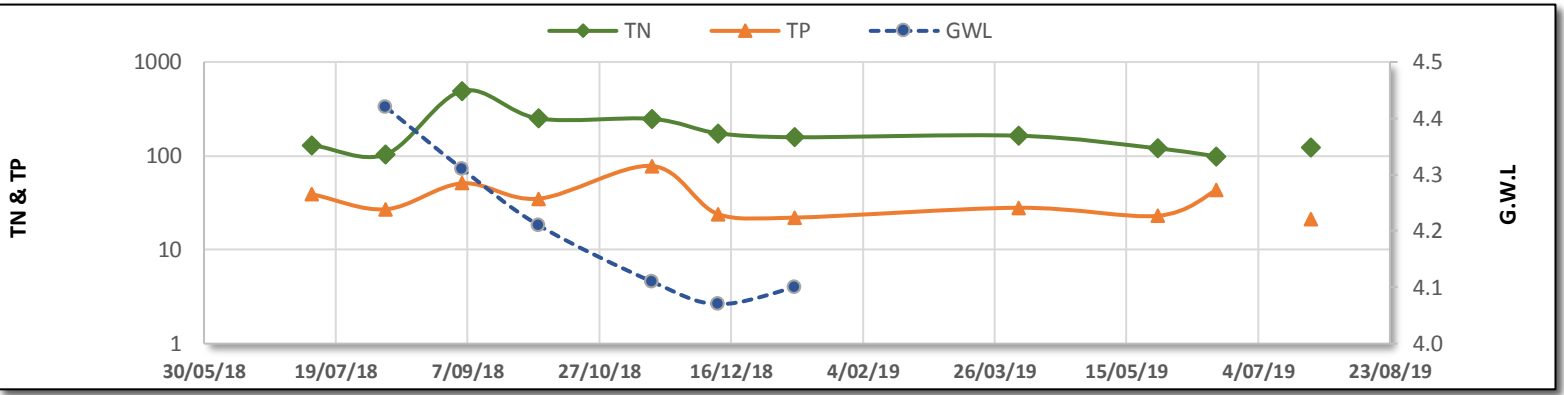
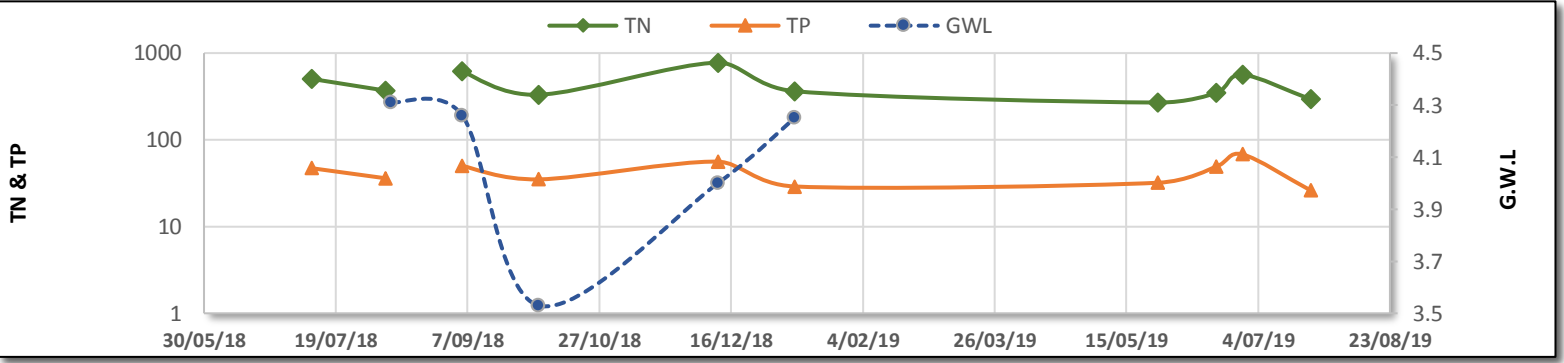
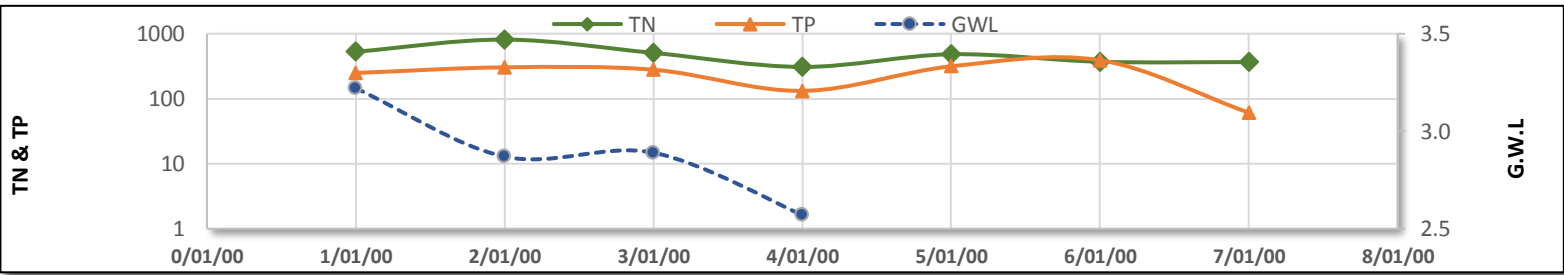
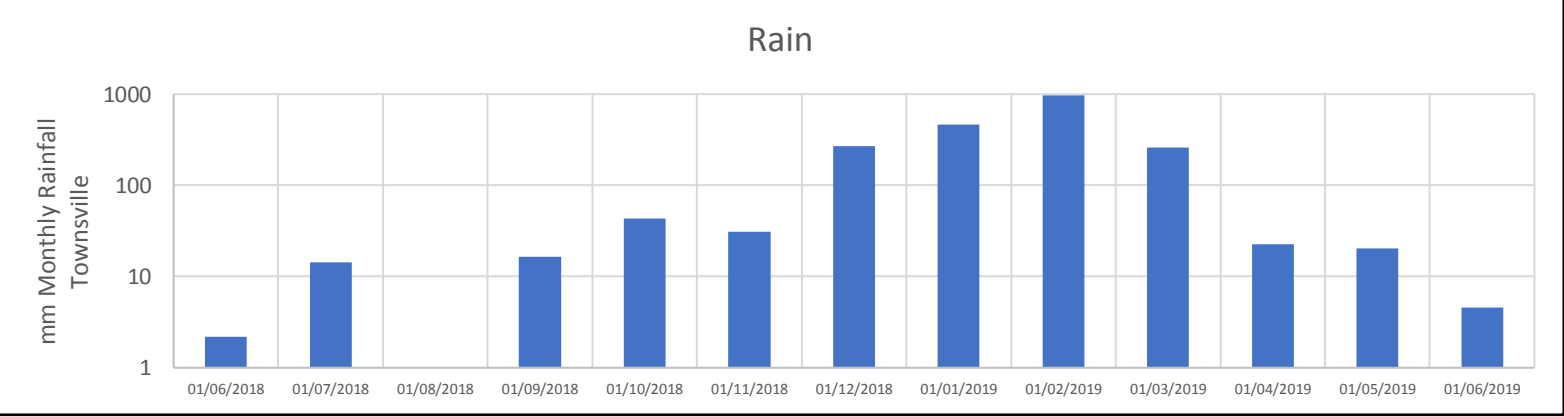
PMB3	10/07/18		17	2	134	503	35	47
	7/08/18		<1	2	78	369	18	36
	9/08/18	4.31						
	5/09/18	4.26	6	2	138	613	24	50
	4/10/18	3.53	1	5	147	331	29	35
	11/12/18	4	<1	<1	99	776	22	56
	9/01/19	4.25	6	<1	135	364	24	29
	27/05/19		5	1	131	269	23	32
	18/06/19		1	<1	157	347	48	49
	28/06/19		16	2	44	563	16	68
	24/07/19		3	2	57	293	11	26

PMB4	9/08/18	3.22	3	1	422	528	224	249
	5/09/18	2.87	18	2	441	812	290	304
	4/10/18	2.89	3	5	404	507	273	279
	16/11/18	2.57	56	2	27	308	43	132
	4/04/19		4	<1	421	483	306	315
	18/06/19		3	<1	349	370	379	391
	28/06/2019 *		2	2	161	366	55	61

NOTES:
The Y axis is logarithmic to represent the large scale span.
Monitoring data is missing for February & March and for PMB level after January 2019.
Graph curves interpolate between points. The rise in groundwater level in January is poorly represented due to missing data.
Rainfall values are the total for the month.
Sampling and field measurements by JBS Townsville
Laboratory analysis by TropWater, Townsville. (E.C. 10/5/18 measured by Bio-Track)
* result atypical, may be incorrect

LOCATION	Electrical Conductivity uS/cm					
Date	10/05/18	4/04/19	27/05/19	18/06/19	28/06/19	24/07/19
PMB#1			96840	97420	96080	95690
PMB#2		3829	4002	4134		4184
PMB#3			9125	9336	9273	9172
PMB#4		1375		17870	48450 *	
TMB1			5524			
TMB2	4790	2235	3634	4513	5057	5034
TMB3	9520	12050	11800	12150	11440	11300
TMB4	12300	3343	1421	7450	8335	9118
TMB5	15110	17800	19260	19840	18980	19520
TMB6	14720	16290	17170	17390	17660	16850

TABLE 1: SUMMARY OF GROUNDWATER ANALYTICAL RESULTS



As a generalisation, groundwater nitrogen increased in the shallow monitoring bores following the flood. The levels then declined and by July, 2019, the nitrogen has returned to the 2018 concentrations. The groundwater salinity varies from moderately saline to hyper-saline. This indicates recharge (deep drainage) and hydraulic flow rates are low to very low. The pH values are within a narrow range and are close to neutral. No significant pH influence (environmental harm or nutrient process effect) is evident.

3.2 Phosphorus In Groundwater

With the exception of TMB2, all phosphorus levels are low. TMB2 phosphorus levels are associated with turbid water in this well. The level is dropping over time with continued purging. Phosphorus from irrigation is being managed through crop removal and soil phosphate sorption. Annual soil phosphorus monitoring shows a low level of soluble phosphorus in the irrigated soil profile. Phosphorus is not considered to be a problem for this site in the short to medium term (0-20 years).

3.3 Permanent Water Bore Assessment

The permanent monitoring bores are used to sample deeper below ground level. This water is thought to represent the dominant aquifer flow. The inlet screen admits water from a depth of approximately 29 metres below ground level.

The nutrient levels for all the permanent bores are relatively constant. Total nitrogen remains below 1 mg N/L for all bores and for all sampling events. Total phosphorus remains below 0.1 mg P/l for PMB1, PMB2 and PMB3. PMB4 is atypical with total P in the range of 0.14 to 0.4 mg P/L. This bore has only recently been returned to service as a monitoring well. It is possible a thorough bore purge using a high volume pump would clean out residual debris and result in a lower phosphorus level. It is also possible this bore contains micro-particulate matter which contributes to total P. A thorough bore purge may correct this issue. Alternatively, the bore may be located in a different soil/sediment type.

The permanent monitoring bores demonstrated a small increase in groundwater level during the high rainfall period. The range is between 0.2 and 0.7 m. Bore log descriptions are not available but the data (change and rate of response) indicates the deeper bores are connected with the surface groundwater.

Unless a much wider groundwater monitoring network is established, it is not possible to identify whether there are other nutrient sources affecting the deeper groundwater. For example it is possible the industrial land further inland provides some small effect on total nitrogen and total phosphorus.

The data indicates there is no measured effect on the deep groundwater nutrient concentration as a consequence of wastewater irrigation. This is consistent with historical monitoring records.

3.4 Temporary Monitoring Bore Assessment

TMB1

TMB1 has only one record for the monitoring period. This is dated 27/5/2019. No level data is available. The bore is dry for the remaining observation dates. The one sample is dominated by the organic fraction. It is expected there was little water in the bore and the result is due to seepage, rather than ground water. The bore was dry in January, 2019. The total nitrogen is 2.5 mg/L and total phosphorus is 0.3 mg/L. If the bore has little water and is not well purged, it is likely bore debris is contributing to the high organic nutrient content.

TMB2

TMB2 starts with a moderate nitrogen concentration in August 2018. The level rises from 0.4 mg N to peak at 103 mg N/L in January 2019. It then declines to 2.4 mg N/L by July 2019. *These nitrogen levels contrast all the other bores.*

Figure 2 provides a summary of the water irrigated to the irrigation area #4. Irrigation area #4 is adjacent to TMB2. Figure 2 also shows the approximate wetted areas. The travelling irrigator stops short of the end of the field as there is a production bore at the end of the field. The production bore is visible directly above (north east of) the TMB2 location. Irrigation was not applied to irrigation area #4 from after November 11, 2018 until July 2019.

Figure 2 shows the change in groundwater nutrient from June 2018 to June 2019. The groundwater nutrient increases after irrigation stops. Figure 2 also shows the change in groundwater level and rainfall for the period. The nutrient level increases sharply from December along with the onset of the high summer rain.

3.5 Possible Sources Of Groundwater Nutrient

There are a number of possible mechanisms that may explain the extremely high groundwater nutrient level observed at TMB2. Three mechanisms are listed and discussed. The mechanisms are not exclusive and all of them will affect the local groundwater.

- 1 Irrigation water infiltration
- 2 Leaching of stored soil nutrient with heavy rain
- 3 Nutrient carried by a local drainage line affecting the adjacent ground water

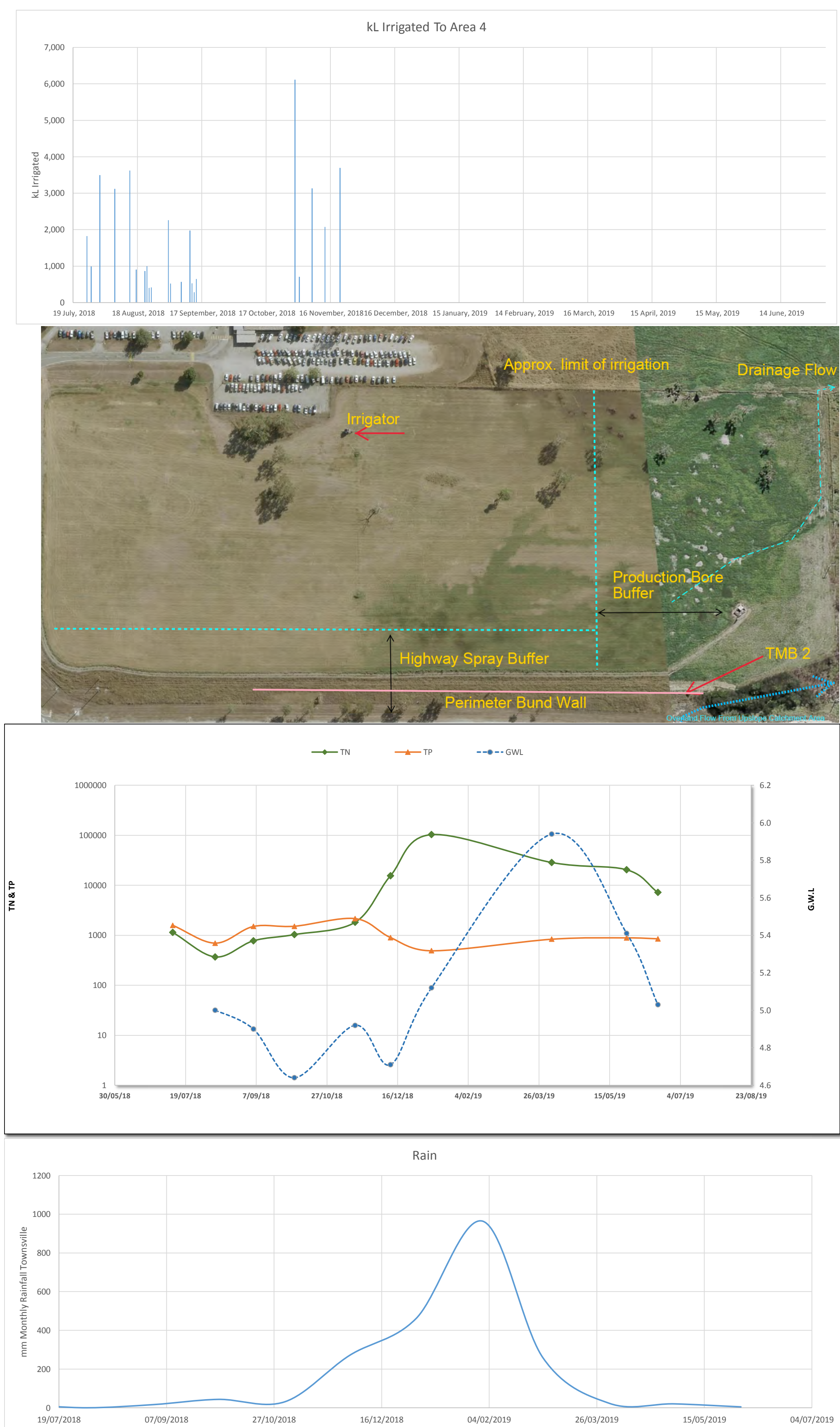


FIGURE 2: TMB2 Groundwater & Adjacent Irrigation

3.5.1 Irrigation Water Infiltration

TMB2 is located on a raised bund wall and irrigation water can not flow down the bore casing.

The irrigation water has approximately 130 mg/L of total nitrogen, mostly in the ammonium form. If irrigation water flows directly to the groundwater then it will increase the surface groundwater to levels approaching 130 mg N/L.

If irrigation is allowed to pond and the soil is highly permeable then water can rapidly drain through the soil profile to reach shallow groundwater. The local soils are poorly permeable clay with a depth of 4 metres to groundwater. There is no obvious preferential flow path to bypass the clay.

Irrigation was applied by a travelling irrigator during the period June to November. There is a rise in groundwater of 0.28 m between October 4 and November 11, 2018.

The BOM record for Townsville records 50.6 mm of rain for this period. This seems insufficient to result in a groundwater rise. In December the trend reverses, the groundwater level falls by 0.21 m. The rainfall for the November 16 to December 11 period is 119 mm.

The irrigated volume applied to area 4 is 12.02 ML for the period October 4 to November 11. The irrigation area is 6.5 hectares. This is equivalent to 186 mm of irrigation during a 38 day period or 4.9 mm/day. The pan evaporation (Townsville BOM site) for this period is 316 mm. For the period October 4 to November 11 rainfall+irrigation is 236.6 mm and evaporation is 316 mm. Assuming no runoff and 10% evaporative loss of irrigation, the net infiltration is 218 mm. If the crop factor is 0.69 then all of the applied irrigation water can be utilised by the crop and as soil evaporation.

The recorded irrigation rate matches the expected irrigation demand for the crop. Irrigation to area 4 ceased on November 11, prior to the major increase in groundwater nutrient. The increased groundwater level for the period October 4 to October 11 does not appear to be a consequence of irrigation water infiltration. Infiltration of irrigation water is not a contributing factor after November 11.

3.5.2 Leaching of Stored Soil Nutrient with Heavy Rain

If the soil has a high level of nitrate nitrogen then leaching of the stored nutrient will increase the groundwater nutrient level. The annual soil monitoring was undertaken by Douglas Partners. A soil sample was collected from irrigation area #4 in May 2019. The sample location is shown in Figure 3. The Douglas report provides soil profile nitrate concentrations for 2018 and 2019. This is copied as Figure 4. There is a loss of nitrate N from the soil profile after the 2018-2019 wet season. This can be attributed, in part, to soil leaching and soil denitrification during the wet summer of 2018-2019.

Soil sampling sites "A" and "B" had a similar nitrate nitrogen content in 2018 with lower levels observed at site "C". The nutrient range is within a range commonly expected for stiff clay soil with a history of fertiliser application but less than that expected for horticultural crops. Site "A" shows nitrate N declining with depth but has 20 mg N/kg at 1400 mm. This nutrient is below the root uptake range and is exposed to leaching or denitrification. Site "B", within the area #4 irrigation area, has no deep nitrate nitrogen in 2018.

The groundwater electrical conductivity provides some indication of the drainage rate. It is also affected by salt applied through irrigation and solution of salt from within the soil and dilution/concentration of salt in the soil water. The lowest E.C. TMB sites also have the highest groundwater nitrogen, but the relationship is weak. TMB2 and TMB4 have more variable electrical conductivity. This indicates more infiltration of fresh water. TMB 3, 5 and 6 are less variable and more saline. This suggests less infiltration for these locations.

Figure 5 illustrates a hypothetical response to a 104 mm leaching event. This is a large event, such as can occur during a flood. In this case it is assumed 90% is leached with no loss of nitrogen through denitrification. This represents a worst case leaching condition. The soil profile nitrogen values are based on the Douglas 2018, site B, test values. The predicted nitrogen concentration in drainage water is 22.5 mg N/L. This is about 20% of the maximum observed in TMB2. If 90% of the nitrogen is leached in 20 mm of drainage water then the concentration would be similar. This is simply due to concentration of a relatively small mass of nitrogen within a small volume of water. It is apparent, the absolute concentration (mg N/L) is less important than the rate of transfer (kg N/ha/y). If the drainage rate is low, then there is more concentration effect. All the bores can be described as saline to highly saline due to this concentration effect. The modest elevation of nitrogen in TMB4 needs to be interpreted with this in mind.

All of the profiles measured show no gross accumulation of nitrate nitrogen that would be expected when the shallow groundwater has an extremely high nitrogen level.



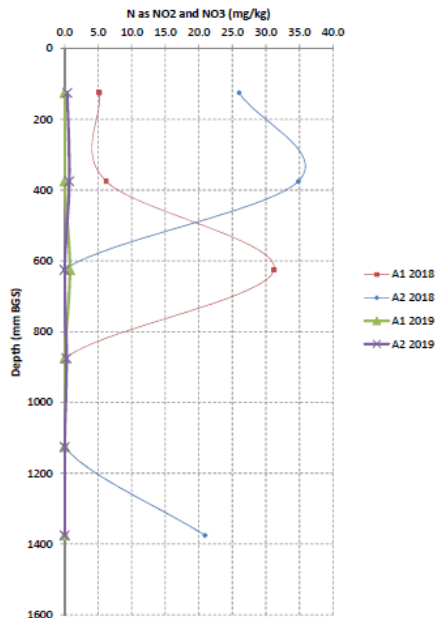
PROJECT No: 93805.02
DRAWING No: 1
REVISION: 0

TITLE: Site Layout and Test Location Plan
Annual Soil Sampling of Pastures
Bruce Highway, Stuart

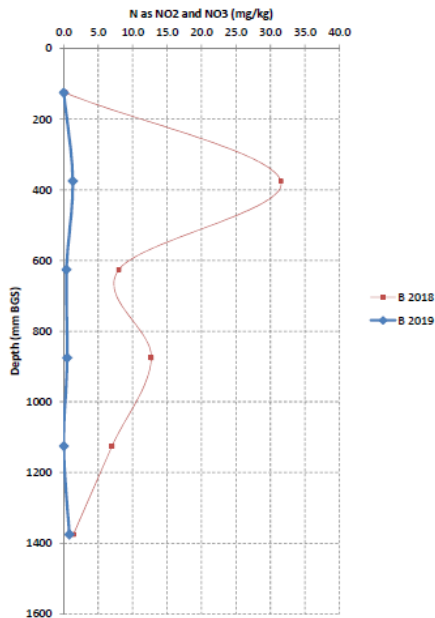
CLIENT: JBS Australia Ltd
OFFICE: Townsville
SCALE: 1:6,886
DRAWN BY: Little
DATE: 10 June 2019

Douglas Partners
Geotechnics • Environment • Groundwater

Nitrate and Nitrite N - TPA / Site A



Nitrate and Nitrite N - TPB / Site B



Nitrate and Nitrite C - TPB / Site C

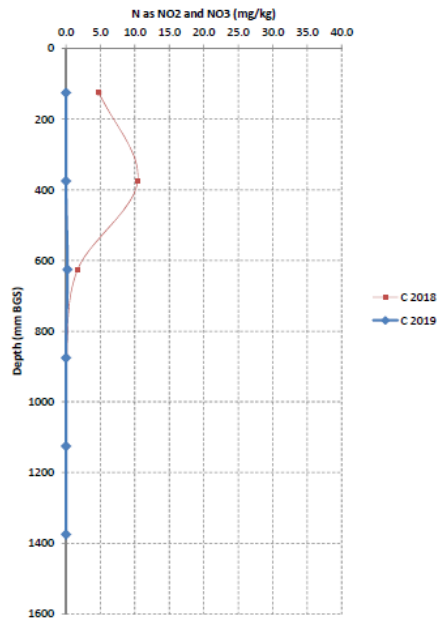
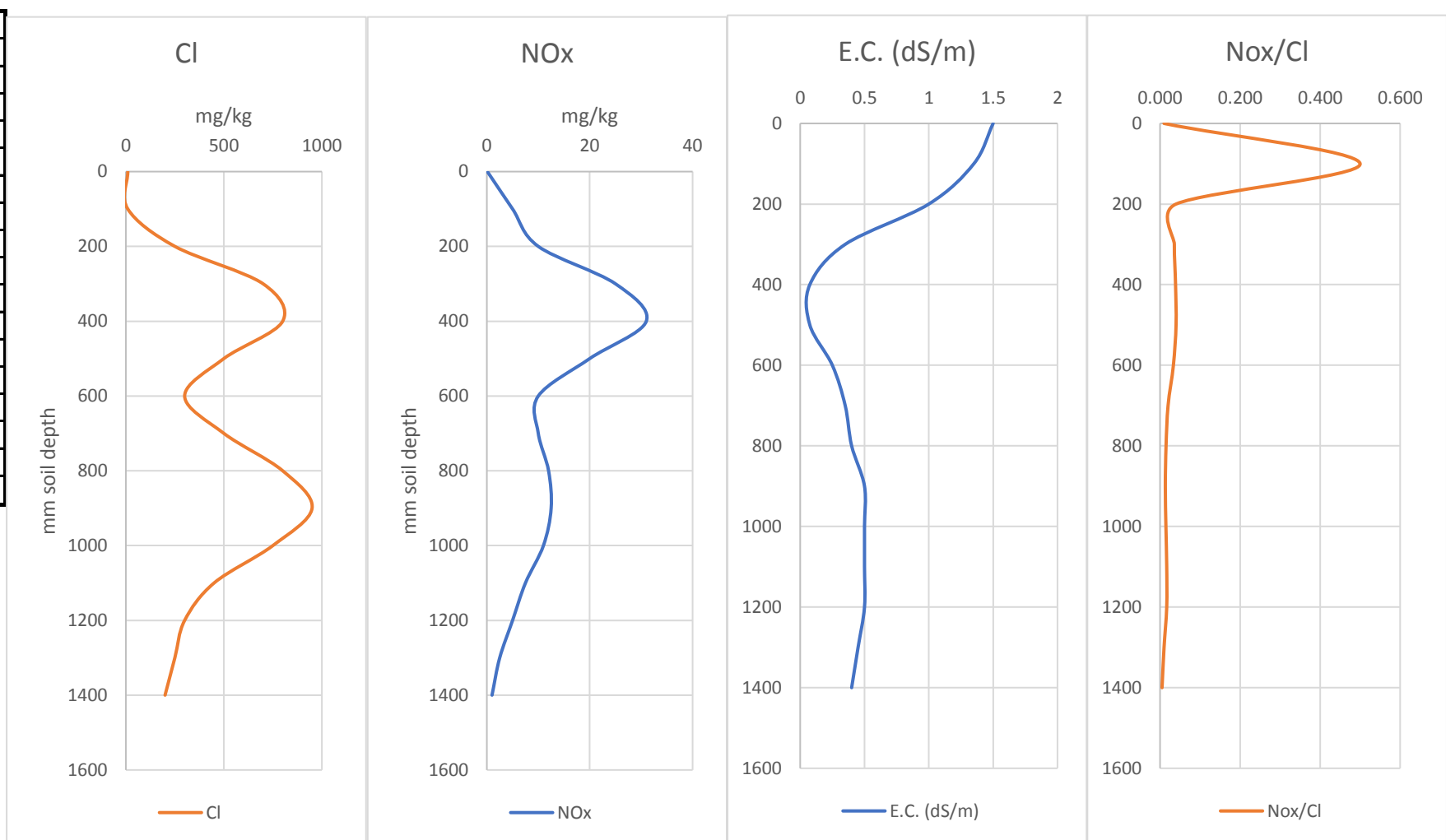


Figure 4: (from Douglas Partners Soil Monitoring Report)

2018 Monitoring Site B				
Depth	Nox	Cl	N/Cl	E.C.
mm	mg/kg	mg/kg	ratio	dS/m
0	0.1	10	0.010	1.5
100	5	10	0.500	1.35
200	10	250	0.040	1
300	25	700	0.036	0.35
400	31	800	0.039	0.075
500	20	500	0.040	0.075
600	10	300	0.033	0.25
700	10	500	0.020	0.35
800	12	800	0.015	0.4
900	12.5	950	0.013	0.5
1000	11	750	0.015	0.5
1100	7.5	450	0.017	0.5
1200	5	300	0.017	0.5
1300	2.5	250	0.010	0.45
1400	1	200	0.005	0.4

Data and location image from Douglas Partners June 2019 Soil Monitoring report.
Note: Data interpolated from 6 measured points.



Nox Leachate Prediction			
Profile Leaching Event	104	mm	Water flow from lower profile depth
Leached Proportion	90%		Proportion of nitrogen leached from the soil profile
Leached Nox	22.5	mg/L	Predicted Nox concentration in drainage water

Figure 5: Profile Nitrate Leaching

The MEDLI model has been used to investigate deep drainage rates and the nitrate concentration. The MEDLI predictions associated with irrigating 55 mm every 3 weeks have been presented in earlier reports associated with this Environmental Evaluation. The predicted long term average nitrate nitrogen concentration in drainage water is 0.3 mg N/L and a peak of 7 mg N/L is predicted. This agrees with the total nitrogen level recorded for the deeper permanent monitoring bores and TMB 3 and TMB6.

TMB 4 and TMB 4 have an average of 1.8 and 1.1 mg N/L.

By contrast, the average for TMB2 is 19.2 mg N/L.

In common with all models, the MEDLI mode is limited by the underlying assumptions. It should not be considered to have the flexibility to address all conditions, no model does this. With that important limitation in mind, the MEDLI model has been used to assess the performance of irrigation area 4 for the period 2017 to 2019. A large number of assumptions are required to attempt this and this will affect the value of the predicted result.

Climatic data exists up to June 2019. To permit MEDLI to model the first half of 2019, climatic data from other years has been used to patch the second half of 2019. Predictions after June, 2019 should be ignored. The intention is to use the extremely high summer (2018-2019) rainfall and assess the effect on groundwater.

A 6 month (approx.) period of irrigation application has been recorded for irrigation area #4. This pattern was recycled for the duration of the modelling period. The irrigation rate is 794 mm/y rather than 490 mm/y which represents the site average. *The model irrigation rate is significantly higher than is practised.* For example, no irrigation was applied to area 4 for the first 6 months of 2019. The MEDLI simulation reflects extremely high nutrient loading rates (750 kg N/ha/y). The predicted nitrate nitrogen leachate concentrations are presented as Figure 6 and Figure 7. The faster draining soil has a higher deep drainage volume. This effectively dilutes the nitrogen. The maximum leachate concentration is 12 mg N/L for the faster draining soil. The slower draining soil remains saturated and drains for months at a time. The predicted nitrate nitrogen concentration is 35 mg N/L in drainage water as a maximum for the slow draining soil. (Slow drainage predictions are shown in Figure 6, faster drainage predictions are shown in Figure 7.) *Please note these predictions apply to extremely high rainfall conditions combined with high rates of irrigation.*

Of interest, the MEDLI model predicts a modest denitrification loss of 5% with the (slow draining) saturated soil. Increasing the loss to 8.8% is sufficient to remove all of the leaching loss. Modelling of denitrification is very difficult due to the large number of variables affecting the process and the need to use a model with inputs that can be supported at an investigative, rather than a research level.

Even if no denitrification occurs, the groundwater nitrogen predicted for extreme conditions remains below the high levels observed in TMB2, when the extremely high rate of irrigation is applied to historical climatic data.

It is concluded leaching of nitrogen stored within the soil profile is insufficient to explain the extremely high groundwater nutrient levels that have been recorded for TMB2. It can explain the smaller increases observed in other shallow monitoring bores.

Slow Deep Drainage 2017-2019

Drainage 177 mm/y

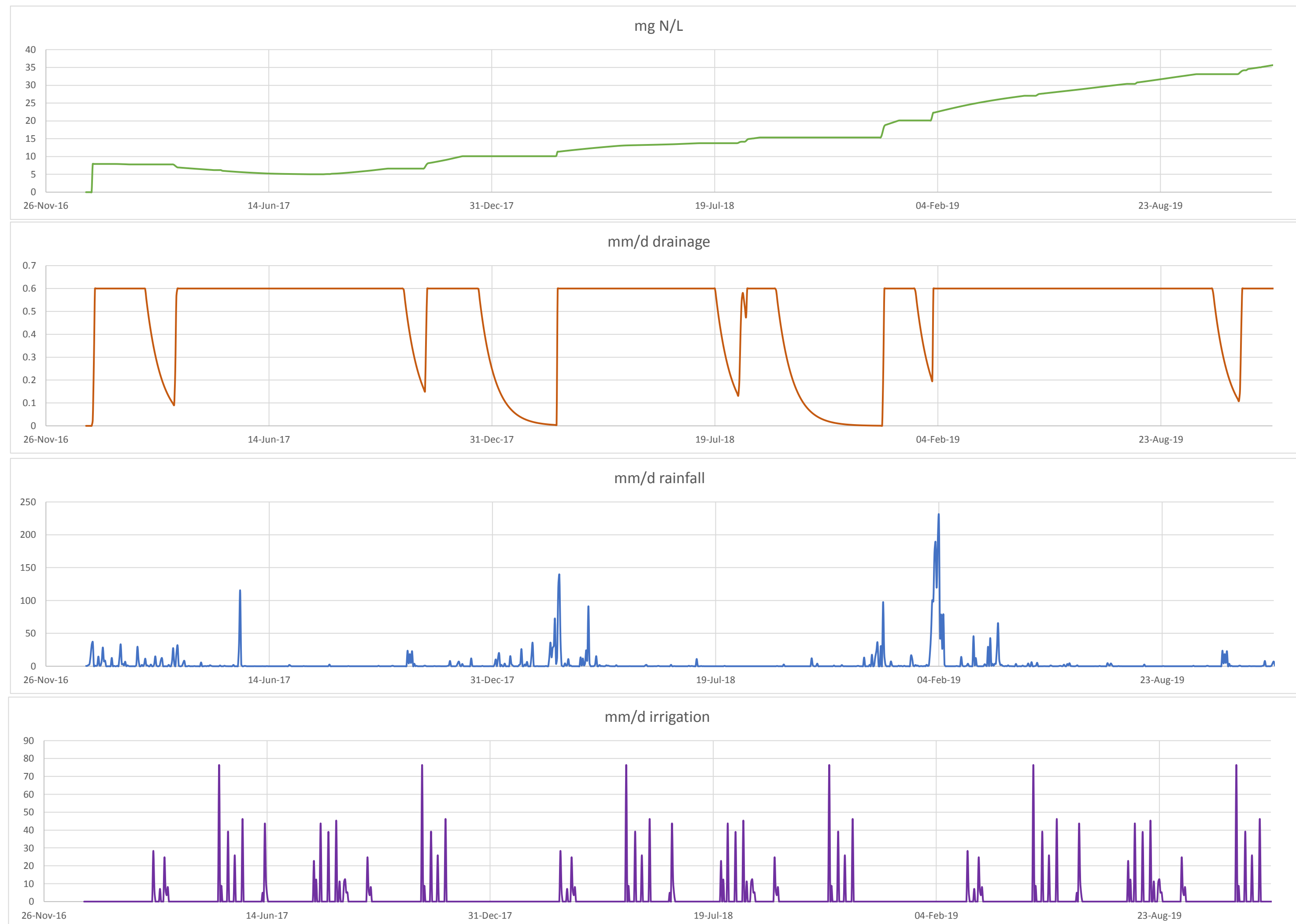


FIGURE 6: MEDLI Predictions For Slow Deep Drainage Rate Soil

Fast Deep Drainage 2017-2019 Drainage 370 mm/y



FIGURE 7: MEDLI Predictions For Faster Deep Drainage Soil

3.5.3 Nutrient Carried by A Local Drainage Line Affecting the Adjacent Ground Water

TMB2 is located immediately adjacent to a drainage line. Figure 8 is a photograph of TMB2 and the culverts over this drainage line below the Bruce Highway.



Figure 8. TMB2 Location and Adjacent Drainage Line

The catchment upstream of TMB2 contains a large industrial area. Figure 9 is an aerial image sourced from Qld Globe. This shows the catchment area. Activities within this catchment have not been studied.

Appendix 2 shows the 1 and 2% return interval (AEP) flood levels for the JBS site and upstream catchment. Flood levels in January 2019 are thought to have been higher than those mapped. Large areas of inundated industrial catchment flow past the TMB 2 location.

If elevated nitrogen is carried in runoff down the drain flowing past TMB2 then it is possible this water has entered the shallow groundwater. No data is available for runoff water quality at this location. It is not possible to determine if runoff from beyond the JBS irrigation area has had an effect on the groundwater at TMB2.



Figure 9: Catchment Upstream Of TMB2

TMB3, TMB5 , TMB6

The monitoring bores TMB 3, TMB 5 & TMB 6 all have a modest nutrient level and show no significant effect associated with nutrient transport from irrigation areas to the shallow groundwater. The test results are summarised in Table 1.

TMB4

This bore shows a spike in groundwater nitrogen following the heavy summer rain. The peak values are consistent with the MEDLI predictions for the design irrigation rate (~ 5 ML/ha/y). The January spike occurs when there was no irrigation. This precludes infiltration of irrigation water.

Figure 11 (following page) shows the surface (0-150 mm) nitrate nitrogen upslope of TMB4 in August 2018. (These samples were collected by Bio-Track Pty Ltd.) There is an elevated patch of nitrate nitrogen at the end of the slope at (location S14) and the beginning (location S5). It is likely uneven distribution of irrigation water is responsible for the uneven distribution of nitrate in the surface soil. This may be due to slow shut-off of the irrigator at the end of a run, leakage from hoses, etc. Figure 10 shows the location of TMB4, relative to the surface flow pathways for the upslope irrigation areas. A relatively large area of irrigated land has a surface drainage pathway that flows within 5 m of TMB2. TMB4 is located in a low point, relative to the surrounding land.

TMB4 is immediately downslope of the end of this irrigation run and is well placed to monitor the effects of uneven irrigation, leaks, etc.

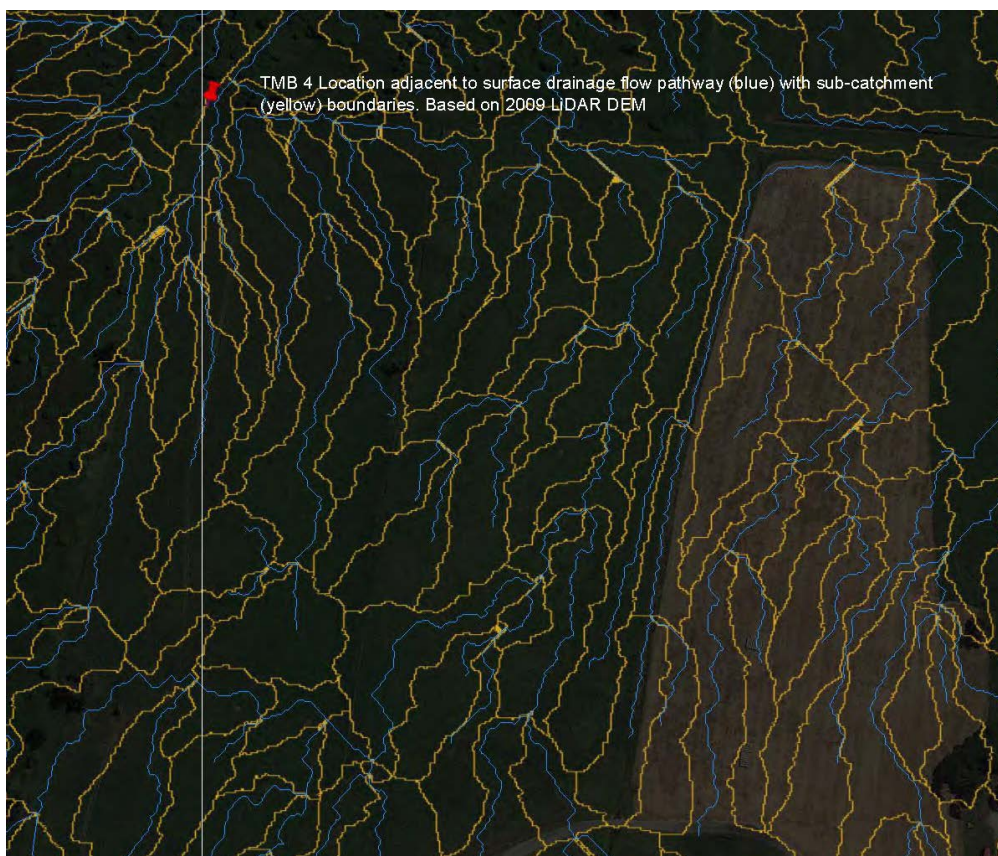


Figure 10: TMB4 and surface drainage pathways



PM4

S15

S14

S13

S12

S11

S10

S09

S08

S07

S06

S05

S04

S03

S02

S01

S16

S17

S20

S18

S1888

S# N as NO3 mg/kg

1 27.5

2 49.1

3 13.4

4 18.7

5 56.8

6 5.3

7 19.5

8 26.5

9 14.5

10 17.6

11 22.8

12 15.0

13 28.7

14 73.3

15 13.4

16 12.5

17 5.4

18 17.3

19 0.3

20 0.5

FIGURE 11: Surface Soil Nitrate Nitrogen

4 Requirement 5 (d)

(d) which describes the extent of any contamination of groundwater;

The deeper groundwater represents the greater majority of the flow. It is not possible to assess the contribution of flow potentially affected by the surface water without a very detailed assessment. It is expected dispersion and mixing limits surface effects to the upper 1-5 metres of local groundwater. This would leave the majority of the deeper groundwater unaffected by surface water. The thickness of the aquifer is unknown but is at least 30 m.

The ground water at TMB2 was significantly affected by elevated nitrogen during the high summer rainfall of 2018-2019. The levels appear to be slowly returning to a base line level of 0.4-0.8 mg N/L This is at the edge of the irrigation area.

The surface water at TMB4 appears to be affected by uneven irrigation at this location. The groundwater spiked at 6.7 mg/L during the wet season and has since declined.

There is no data to indicate there has been a significant migration of wastewater nitrogen beyond the licensed irrigation area or that there was any effect on the main aquifer flow. The extent of irrigation effect appears confined to small areas of shallow groundwater, located within the irrigation areas. It is inconceivable the nitrogen has migrated from bores TMB 3-6 to significantly affect the aquatic environment or wetland habitat areas or to affect surface water quality.

5 Requirement 5 (e)

- (e) **which provides an evaluation of reasonable and practicable remediation measures of any identified impact to environmental values; and**
- (f) **which recommends the most appropriate remediation measure and provides a work program to implement the recommendations with estimated timeframes**

5.1 Remediation Measures

The soil will naturally lose nitrogen, albeit slowly for deeper groundwater. The current monitoring shows this trend after the January flood event. Provided inputs are reduced then groundwater nitrogen levels will decline. It is not possible to describe the industrial activities in the catchment upstream of TMB2 or provide remediation measures for off-site activities.

Within the JBS irrigation areas the following actions can be considered as mechanisms to reduce nitrogen movement in deep drainage water:

- 1 Review harvesting processes and contractor management to ensure seasonal start-up and ongoing harvesting is scheduled appropriately and to ensure that 50 hectares of land is irrigated during the year.
- 2 implement a review of irrigation equipment and procedures to identify procedures where irrigation water is not applied uniformly across the irrigation areas. This may require repairs, investment in new equipment, etc. It may also require training to ensure equipment is maintained and operated appropriately.
- 3 continue groundwater monitoring of the temporary monitoring bores for a further period to gather information. (Bores TMB1 and TMB2 will be relocated due to construction of a local authority sewer line through this area.) The existing monitoring period contains some extreme rainfall conditions which are atypical of the normal process.
- 4 A review of the groundwater monitoring schedule is recommended. This would assess the most appropriate location to monitor, the frequency of monitoring and the analytes measured. A regular schedule does not reflect periods of increased sensitivity or response. For this site, the period January to May, is the period when leaching of nutrient into shallow groundwater is most significant. The deeper permanent monitoring bores change less over time and a lower frequency of sampling is appropriate.

5.2 Recommendations

- * All of the measures listed in Section 5.1 are easily adopted with the existing JBS resources.
- * All these measures are recommended.
- * A six month period for assessment is suggested.

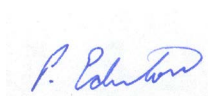
This report has been prepared by Peter Edmiston B.App.Sc.(Hons), M.Phil. for and
on behalf of
Bio-Track Pty Ltd (ABN 91 056 237 275).

Peter Edmiston
Director Bio-Track

Technical Assistance

The evaluation of technical reports is sometimes difficult. Bio-Track remains available to answer questions regarding this report. Users of this report are encouraged to contact Peter Edmiston on (07) 3289 7179 or email queries to pe@biotrack.com.au to resolve technical issues raised within this report that require clarification.

Yours faithfully,



Peter Edmiston.

Bio-Track Pty Ltd 31 July, 2019