NSW DEPARTMENT OF PRIMARY INDUSTRIES

AUGUST 2018

SITE SUMMARY STATUS REPORT

GEORGE DOWNES DRIVE, MANGROVE MOUNTAIN, NSW

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Site summary status report
George Downes Drive, Mangrove Mountain, NSW

NSW Department of Primary Industries

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A	7 August 2018	Draft

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TABLE OF CONTENTS

ABBREVIATIONS

ANZECC	Australian & New Zealand Environment & Conservation Council
BOD	Biochemical oxygen demand
BTEX	Benzene, toluene, ethyl benzene, xylene
DP	Deposited Plan
DPI	Department of Primary Industries
DQO	Data Quality Objectives
EPA	Environment Protection Authority
GCL	Geo-composite clay liner
GME	Groundwater monitoring event
LEP	Local Environmental Plan
mAHD	Metres Australian Height Datum
mBTOC	Metres below top of casing
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NHMRC	National Health & Medical Research Council
PAH	Polycyclic aromatic hydrocarbons
PPM	Parts per million
PQL	Practical quantitation limit (of chemical concentration)
QA/QC	Quality assurance & quality control
RPD	Relative percentage difference
SAQP	Sampling analysis and quality plan
SWL	Standing water level
TOC	Total organic carbon
TDS	Total dissolved solids
TKN	Total Kjeldahl Nitrogen

1 INTRODUCTION

1.1 BACKGROUND

An outbreak of a poultry disease, known as Newcastle Disease, occurred at Mangrove Mountain on the Central Coast Plateau in 1999. Approximately two million carcasses of slaughtered poultry and associated shed litter and wastes were buried to contain the potential spread of the disease. The poultry carcasses were placed inside tar-lined shipping containers, which were placed into engineered burial pits at George Downes Drive (on the former Hymix Kulnura Quarry site) and Bloodtree Road (on Gosford City Council's Mangrove Mountain Works Depot site). Shed litter, manure and other potentially virus-contaminated materials were buried at a third site located at Waratah Road, Mangrove Mountain.

Subsequently, NSW Department of Primary Industries (DPI, Agriculture), working in collaboration with DPI Water, NSW Environment Protection Authority, the Central Coast Public Health Unit of the Central Coast Area Health Service, and contracted environmental consultants (Robert Carr & Associates Pty Ltd.) developed a groundwater monitoring program to monitor any potential environmental impacts resulting from the presence of the burial pits. The groundwater monitoring program commenced in January 2001, following "baseline" groundwater monitoring events undertaken in 1999. Groundwater monitoring events (GMEs) were conducted by various consultants between 2001 and 2018. Presently, there are 19 groundwater monitoring wells located across the three sites.

DPI Agriculture commissioned WSP Australia Pty Limited (formerly WSP | Parsons Brinckerhoff Australia Pty Ltd) to undertake the bi-annual groundwater monitoring program at the three sites for three years (2015 to 2018).

This report presents a summary of results for key groundwater indicators from all GMEs undertaken at the George Downes Drive site by WSP Australia Pty Limited (WSP) since 2015, which comprise:

- WSP | Parsons Brinckerhoff (2017a) Groundwater monitoring event 18, Mangrove Mountain poultry burial sites, dated 4 January 2017 – November 2015 GME – Rev. C
- WSP | Parsons Brinckerhoff (2017b) Groundwater monitoring event 19, Mangrove Mountain poultry burial sites, dated 20 February 2017 – June 2016 GME
- WSP | Parsons Brinckerhoff (2017c) Groundwater monitoring event 20, Mangrove Mountain poultry burial sites, dated 20 February 2017 – October 2016 GME
- WSP (2017 d) Groundwater monitoring event 21, Mangrove Mountain poultry burial sites, dated September 2017 – March 2017 GME
- WSP (2018a) Groundwater monitoring event 22, Mangrove Mountain poultry burial sites, dated March 2018 – November 2017 GME
- WSP (2018b) Groundwater monitoring event 23, Mangrove Mountain poultry burial sites, dated July 2018 (draft) – March 2018 GME

This report presents information and data specifically for the George Downes Drive site. Separate reports have been produced for the Bloodtree Road and Waratah Road landfills.

1.2 PURPOSE OF THIS REPORT

The purpose of this summary report is to document the condition of the groundwater in the vicinity of the containment cell and the physical condition of the cell, particularly with respect to any impacts that may have arisen from possible breaches of the containment of chicken wastes.

1.3 OBJECTIVES

The objectives of the regular groundwater monitoring events (GMEs) and visual inspections were to:

- determine the present occurrence, nature and extent of contamination.
- determine the existence of or potential for off-site transport of contaminants and the associated environmental risks; and, should contamination and/or associated off-site risks exist.
- identify and recommend appropriate mitigation/remedial measures, or otherwise provide a monitoring strategy.

1.4 LIMITATIONS AND INTELLECTUAL PROPERTY

SCOPE OF SERVICES

This site summary report (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and WSP (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

In preparing the report, WSP has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, WSP has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. WSP will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

ENVIRONMENTAL CONCLUSIONS

In accordance with the scope of services, WSP has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Also, it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the client and no other party. WSP assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of WSP or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

2 SITE BACKGROUND

2.1 SITE IDENTIFICATION AND DESCRIPTION

The Mangrove Mountain region is located in the municipality of Gosford City Council (Council), approximately 85 km north of Sydney. This report presents information and data specifically relating to the poultry burial pit at the George Downes Drive site, which was a former Hymix Quarry site. The identification details for the site are provided in Table 2.1 and the location is indicated in Figure 1 and Figure 2 (Appendix A).

Table 2.1 Site identification details

IDENTIFICATION	GEORGE DOWNES DRIVE
Council	Gosford
County	Northumberland
Parish	Kooree
Title identification	Lot 2 DP 233808
MGA co-ordinates (zone 56)	333922 E, 6318807 N

The area surrounding the site comprises well developed agricultural and horticultural industries, including intensive poultry farms, the quarry, orchards, vegetable market gardens and more recently groundwater extraction for bottling. The established agricultural areas are surrounded by native bushland areas including the Dharug, Popran and Brisbane Water National Parks, the McPherson, Olney and Ourimbah State Forests, and other Crown Land.

The George Downes Drive site is located on the Hanson Kulnura quarry site (formerly referred to as the Hymix site), and is accessible via the quarry office and weighbridge. The burial pit is located in the area northeast and upslope of the quarry overburden emplacement area, and is about 60 m west from George Downes Drive. Tar-lined steel shipping containers housing poultry carcasses were placed in a 60 m long trench, which varied in depths between 6 and 8 m. The pit was capped with 3 m of clay. The layout of the site is shown in Figure 3 in Appendix A.

2.2 TOPOGRAPHY

The site is located between the villages of Kulnura and Mangrove Mountain on a sandstone plateau which drains into the Warre Warren Creek, Wyong River, Ourimbah Creek and Brisbane Water catchments. Several small creeks and tributaries of the Hawkesbury River, including Mangrove, Mooney Mooney and Popran Creeks drain the area. Mangrove Creek has an urban water supply dam in its upper catchment, providing drinking water to the Gosford-Wyong local government areas. The site topography features undulating sandstone ridge-tops, vegetated by temperate sclerophyll woodland.

2.3 GEOLOGY

A review of the Gosford-Lake Macquarie 1:100,000 (1994) geological map indicates that the sites are generally underlain by Hawkesbury Sandstone. The Hawkesbury Sandstone consists of inter-bedded layers of sandstone (massive and sheet facies), siltstone and shale. Upper horizons of this formation are typified by weathered material consisting of permeable sands and heavy clays.

The soils in the vicinity of the George Downes Drive burial pit are developed on material from mixed igneous rock (i.e. basalt) and sandstone according to a more comprehensive map of soils of the central coast plateau (Hawkins and Haddad, 2011). The soils are characterised by a duplex texture profile (i.e. red duplex), a smooth-ped fabric in the B horizon, superplastic clays and no gravel.

The available boreholes did not appear to have encountered any of the basalt in the subsurface profiles, as would have been expected from the review of geological maps.

2.4 HYDROGEOLOGY

The aquifer in the Hawkesbury Sandstone has both porous and fractured flow. It is recharged by rainfall and discharges as springs and to surface water systems that flow from the Mangrove Mountain plateau.

Perched aquifers are common across the area in the weathered material, with the more productive aquifers, commonly used for commercial and domestic purposes, located at depths below 20 metres. There is potentially a hydraulic connection between the perched and upper sandstone aquifer, however the degree of connection at the site is not well known.

2.5 REGISTERED GROUNDWATER BORES

A search of the NSW Office of Water groundwater database (www.nratlas.nsw.gov.au) indicated that several groundwater bores are registered within 500 m of the site. The recent review of the database (http://allwaterdata.water.nsw.gov.au/water.stm) (on 22 April 2015) did not identify any new bores in the vicinity of the site. A summary of the registered bores and their distance from the George Downes Drive site is provided in Table 2.2 and shown in Figure 2 in Appendix A.

Table 2.2 Summary of registered bores with 500 m radius of the site

SITE	BORE ID	PURPOSE	APPROXIMATE DISTANCE AND DIRECTION FROM SITE(1)	SCREEN DEPTH INTERVAL (m)	STANDING WATER LEVEL (mBTOC)	TOTAL DEPTH (m)
George Downes Drive(2)	GW066748	Domestic/stock	305 m north-east	5.8 – 40	7.0	40.0
	GW202450	Domestic/stock	352 m south	0 – 72	Unknown	72.0
	GW200549	Domestic/stock	448 m north-east	12 – 79	40	79
	GW048032	Domestic/stock	442 m south-south-west	6 – 74.3	24	74.3
	V113642(3)	Domestic/stock	193 m south-east	6.4 - 69	27.6	69

(1) Distances are approximate only –calculated based on best judgement.

(2) Figure 2 in Appendix A shows two bores (GW066748 and GW202450) are located within the 500 m of the site. However, the close proximity of bores GW200 549 and GW048032 to the 500 m line suggested these bores may also be within the 500 m buffer zone.

(3) Information provided by NSW DPI. This bore is not shown on the public database. “V113642” refers to the bore license number, rather than the bore ID.

3 CONTAMINANTS OF CONCERN AND APPLICABLE CRITERIA

3.1 CONTAMINANTS OF CONCERN

The contaminants of concern for the GMEs at George Downes Drive, as identified in the SAQP (Parsons Brinckerhoff, 2013), are presented in Table 3.1.

Table 3.1 Contaminants of potential concern

CONTAMINANT	JUSTIFICATION
Total dissolved solids (TDS) Major anion and cation concentrations (chloride, sulphate, bicarbonate, magnesium, calcium, potassium and sodium) Biochemical oxygen demand (BOD) Electrical conductivity (EC) Dissolved oxygen Alkalinity (bicarbonate, carbonate, hydroxide and total)	Assessment of general water quality.
Nutrients (ammonia, nitrate and nitrite, total Kjeldahl nitrogen (TKN), total nitrogen and total phosphorus	Assessment of breakdown of organic matter placed within the burial pits and maturing of the waste material over time.
Metal concentrations (arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc)	Assessment of potential corrosion of the metal containers containing the carcasses and waste.

3.2 GROUNDWATER INVESTIGATION LEVELS

With reference to the National Environmental Protection (Assessment of Site Contamination) Measure as amended in 2013 (NEPM, 2013), the groundwater investigation levels adopted for assessing the quality of groundwater for the George Downes Drive site are summarised in Table 3.2. These investigation levels were selected to assess the potential risks to human and freshwater ecosystems. The environmental and human receptors identified on-site and off-site include:

- Workers conducting monitoring or maintenance works at the sites.
- Users of the groundwater in the vicinity of the site. Groundwater quality would permit several beneficial uses including irrigation, stock, domestic and potable use. Groundwater in the surrounding area is also used for bottling and sale as mineral spring water.
- Aquatic ecosystems in the surface waters down gradient of the site (Ourimbah Creek, Warre Warren Creek, Bull Gully and Broula Gully). In addition, spring-fed streams were previously identified in the area.
- Surface water users, including Gosford-Wyong Council’s Water Supply Authority, on the catchment streams of Warre Warren Creek and Mangrove Creek downstream of Warre Warren Creek.

The rationale for selecting the investigation levels presented in Table 3.2 was detailed in the SAQP (Parsons Brinckerhoff, 2013). When the guidance values are not provided in the NEPM 2013, the parent guidelines were referenced.

Table 3.2 Groundwater investigation levels

ANALYTE	UNIT	DRINKING WATER GUIDELINES[(1),(2)]	PROTECTION OF FRESHWATER ECOSYSTEM [(1),(3)]	LIVESTOCK DRINKING WATER[(4)]	IRRIGATION USE[(5)]
Indicators					
pH	-	6.5 – 8.5	6.5 – 8.0	-	6.5 – 8.5
Total dissolved solids	mg/L	600	-	2,000 – 10,000	-
Biochemical oxygen demand	mg/L	-	-	-	-
Chemical oxygen demand	mg/L	-	-	-	-
Anion					
Total alkalinity	mg/L	-	-	-	-
Hydroxide	mg/L	-	-	-	-
Carbonate	mg/L	-	-	-	-
Bicarbonate	mg/L	-	-	-	-
Chloride	mg/L	250	-	-	-
Sulfate	mg/L	500	-	2,000	-
Cations					
Calcium	mg/L	-	-	1,000	-
Magnesium	mg/L	-	-	-	-
Potassium	mg/L	-	-	-	-
Sodium	mg/L	180	-	-	-
Nutrients					
Ammonia (as NH_3-N) [(6)]	mg/L	0.41[(7)]	2.57[(8)]	-	-
Nitrate (as N) [(6)]	mg/L	11.3[(7)]	0.16 [(9)]	338	-
Nitrite (as N) [(6)]	mg/L	0.91[(7)]	-	9.12	-
Nitrate + nitrite (as N)	mg/L	-	0.04	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	-
Total nitrogen	mg/L	-	0.35	-	0.5
Phosphorus	mg/L	-	0.025	-	0.05

ANALYTE	UNIT	DRINKING WATER GUIDELINES(1),(2)	PROTECTION OF FRESHWATER ECOSYSTEM (1),(3)	LIVESTOCK DRINKING WATER(4)	IRRIGATION USE(5)
Metals					
Aluminium	µg/L	200(11)	55(10)	5,000	-
Arsenic	µg/L	10	-	500 – 5,000	100
Arsenic (as AsIII)	µg/L	-	24	-	-
Arsenic (as AsV)	µg/L	-	13	-	-
Barium	µg/L	2,000	-	-	-
Boron	µg/L	4,000	370	5,000	500
Cadmium	µg/L	2	0.2	10	10
Chromium (CrVI)	µg/L	50	1.0	1,000	100
Cobalt	µg/L	-	-	1,000	50
Copper	µg/L	2,000	1.4	400 – 5,000	200
Iron	µg/L	300	-	-	200
Lead	µg/L	10	3.4	100	2,000
Manganese	µg/L	500	1,900	-	200
Mercury	µg/L	1	0.06	2	2
Nickel	µg/L	20	11	1,000	200
Zinc	µg/L	3,000	8	20,000	2,000

(1) NEPM (2013) Schedule B1 – Investigation levels for soil and groundwater

(2) NHMRC/NRMMC (2011) Australian Drinking Water Guidelines. (Note: Human health values are provided as priority, aesthetic values are only provided in the absence of a human health value)

(3) ANZECC/ARMCANZ (2000) – trigger values for the protection of 95% of freshwater ecosystem

(4) ANZECC/ARMCANZ (2000) – recommended water quality trigger values for livestock drinking water

(5) ANZECC/ARMCANZ (2000) – Agricultural irrigation water long term trigger values

(6) 1 mg/L of NH_3-N = 1.21 mg/L of NH_3; 1 mg/L of NO_3-N = 4.43 mg/L of NO_3; and 1 mg/L of NO_2-N = 3.29 mg/L of NO_2.

(7) The guideline values for drinking water are: 0.5 mg/L ammonia (as NH_3), 50 mg/L nitrate (as NO_3) and 3 mg/L (as NO_2).

(8) Ammonia/ammonium equilibrium concentration is highly dependent on pH and temperature. In the ANZECC/ARMCANZ (2000) guidelines, the trigger values for ammonia were derived for pH 6 to 9; extrapolation outside this range is not advisable. On account that the groundwater at the three burial sites is generally of acidic conditions, ammonia concentration for pH 6 is adopted here.

(9) The guideline value for the protection of 95% of freshwater ecosystem is: 0.7 mg/L nitrate (as NO_3).

(10) ANZECC (2000) only provide criteria for Aluminium where the pH of the groundwater is >6.5

(11) NHMRC/NRMMC (2011) values for Aluminium are aesthetic criteria in the absence of health-based criteria.

4 REVIEW OF STANDING WATER LEVELS AND GROUNDWATER FLOW DIRECTION

4.1 GROUNDWATER LEVELS

The relative difference in the standing water level (SWL) in the groundwater monitoring bores is used to calculate the direction of groundwater flow.

The poultry burial pit is located in the catchment area of Warren Creek, which flows through the McPherson State Forest and into Mangrove Creek west of the site.

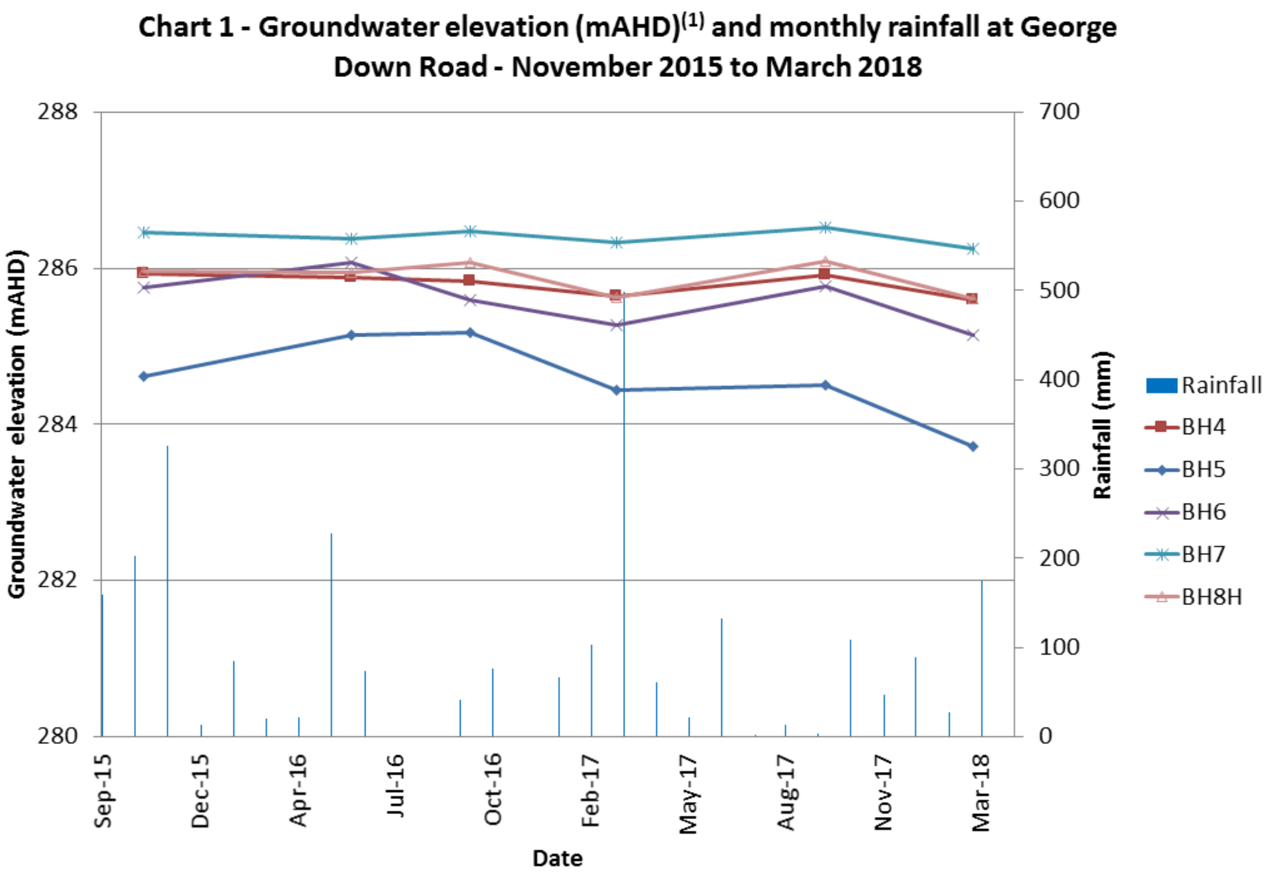
Table 4.1 presents the location, elevation and last recorded SWL (March 2017) of the groundwater monitoring bores on the site.

Table 4.1 Gauging results for March 2018 – George Downes Drive site

BOREHOLE ID	EASTING	NORTHING	T.O.C. ELEVATION (mAHD)	SWL (mBTOC)	GROUNDWATER ELEVATION (mAHD)
BH4	333952	6318803	316.945	31.360	285.585
BH5	333888	6318865	309.350	25.628	283.722
BH6	333869	6318809	310.015	24.880	285.135
BH7	333891	6318819	311.480	25.235	286.245
BH8H	333921	6318890	310.510	24.900	285.610

(1) Abbreviations: T.O.C. – top of casing; mBTOC – metres below top of casing, mAHD – metres Australian Height Datum, mBGL – metres below ground level

Monitoring well BH4 is considered to be the up gradient well, while BH5 and BH7 are considered to be the down gradient well.



(1) The monthly rainfall data was obtained from the mangrove mountain AWS (Bureau of Meteorology Automated Weather Station 061375.

Chart 1 shows groundwater elevations from November 2015 to March 2018 in the five groundwater monitoring wells located at George Downes Drive. The groundwater elevation in the primary monitoring wells ranged between 283.722 mAHD and 286.525 mAHD over the three-year period. Groundwater elevation in each monitoring well did not fluctuate much over time, with most variation evident in BH5. Groundwater elevations in the down gradient monitoring well (BH5) is noticeably lower in elevation than groundwater levels in BH6, BH7 and BH8H, and the nominated up gradient deep monitoring well (BH4), based on surface landscape features. The groundwater elevation in BH7, and in some cases in BH8H, is slightly higher than that measured in the nominated up gradient bore, BH4. Long-term trends in groundwater elevation and rainfall are presented in Appendix A (Figure 4).

All the primary groundwater monitoring wells had SWLs above the well screen, a consequence of the hydraulic head (pressure) in the semi-confined aquifer.

4.2 GROUNDWATER FLOW DIRECTION

The gauging data presented in Table 4.1 showed that groundwater has a predominantly north-westerly flow direction in March 2018 though some mounding associated with the pit appears likely. The inferred groundwater flow direction is presented on Figure 3 (Appendix A).

The recent gauging data (Table 4.1) suggests the burial pit may be causing some localised impact on the groundwater flow directions particularly around BH7 - the closest location to the toe of the pit. At this location groundwater mounding appears to be occurring – relative to other bores. Possible explanations include:

- a result of increased overland flow across the cap, percolating downward at the extremities of the cell;

- increased recharge though the cap, into the cell and, if the cell is not tight, increased head in surrounding bores;
- possibly the more elevated groundwater pressure measured near BH7 may be caused by that portion of the site having minimal trees whereas other bores (e.g. BH4 and BH8H) are surrounded by established trees that through deep transpiration could be lowering groundwater levels compared to the vicinity of the cell.

This localised mounding may be causing some localised flow radially from the site in all directions as shown, however, based on historical data, and topographical information the dominant flow is likely be to the west, north west and south west, in sympathy with the topography. As the roadway to the east follows the ridge, there is likely to be a groundwater divide in the vicinity of the road forming the upper extent of the groundwater catchment.

5 GROUNDWATER QUALITY

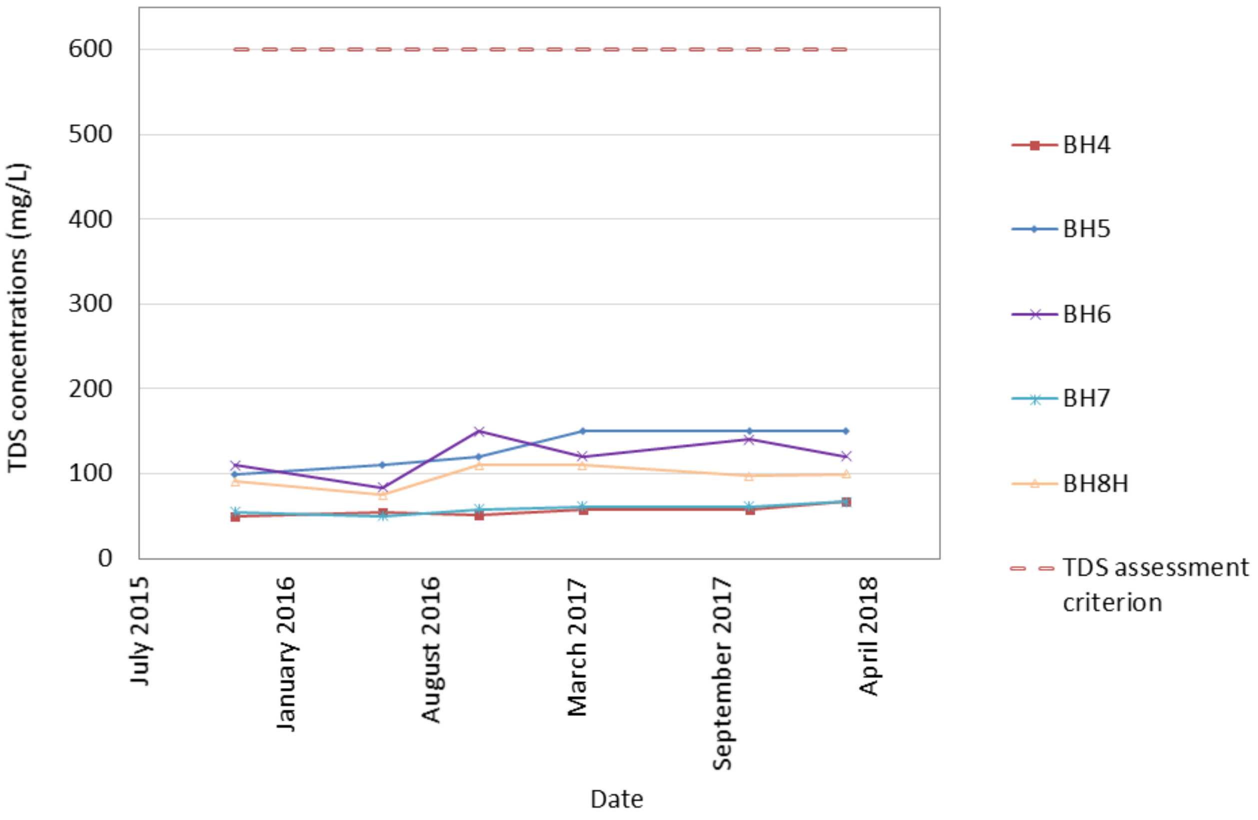
Trends in groundwater quality and exceedances of adopted assessment criteria (where applicable) are presented below. This report focuses upon the trends and exceedances in the down gradient monitoring well BH5, because monitoring the quality of groundwater leaving the pit is a major focus of the program. Data for key contaminants is presented for all groundwater monitoring wells and groundwater assessment levels (see Table 3.2) are also presented, where relevant. Note that in the charts reported through the report, concentrations lower than the LOR were represented as 0 mg/L for nutrients and as 0 µg/L for metals and metalloids.

5.1 TOTAL DISSOLVED SOLIDS

5.1.1 TRENDS

The total dissolved solids (TDS) concentration in groundwater is a measure of all dissolved substances in groundwater, including inorganic and organic substances dissolved in either a molecular, ionised or fine colloidal form. TDS is not a contaminant of concern but it is an indicator of aesthetic characteristics of drinking water, and an indicator of the potential presence of contaminants of concern. TDS data provides a broad indication of fluctuations in the chemical composition of groundwater.

Chart 2 - Trends in TDS concentrations at George Downes Road



As shown on Chart 2, concentrations of TDS were generally consistent in each well throughout the monitoring period. However, variation was observed between the wells on the site with TDS concentrations ranging from as low as 50 mg/L in the up gradient well BH4 to concentrations of 150 mg/L in wells BH5 and BH6. These results are all consistent with very fresh groundwater.

5.1.2 EXCEEDANCES

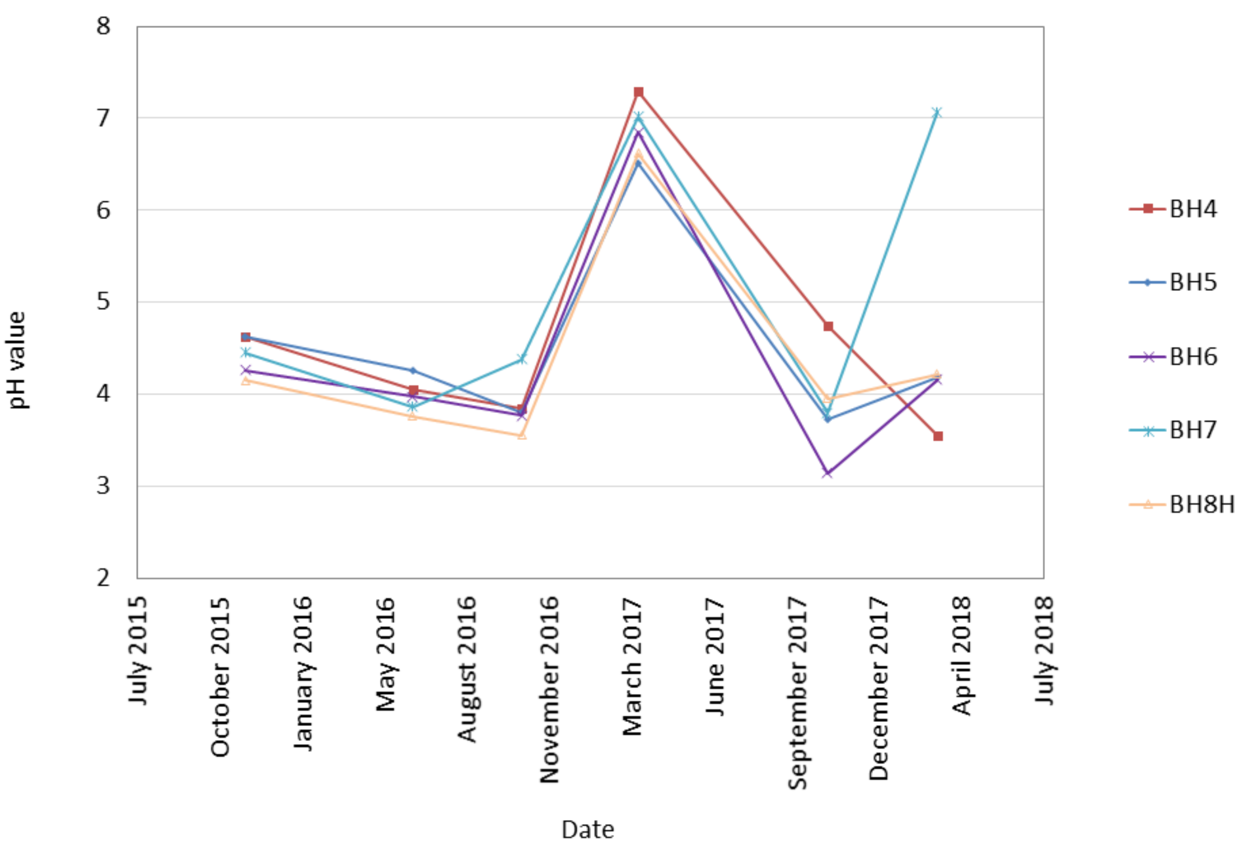
TDS concentrations were consistently below the adopted assessment criteria of 600 mg/L for drinking water in all wells from November 2015 to March 2018.

5.2 pH

5.2.1 TRENDS

Groundwater at George Downes Drive and in the vicinity of Mangrove Mountain is generally acidic, which is common in groundwater associated with the Hawkesbury Sandstone formation. Chart 3 presents pH values measured in the field in each deep well on the site from November 2015 to March 2018.

Chart 3 - Trends in pH at George Downes Road

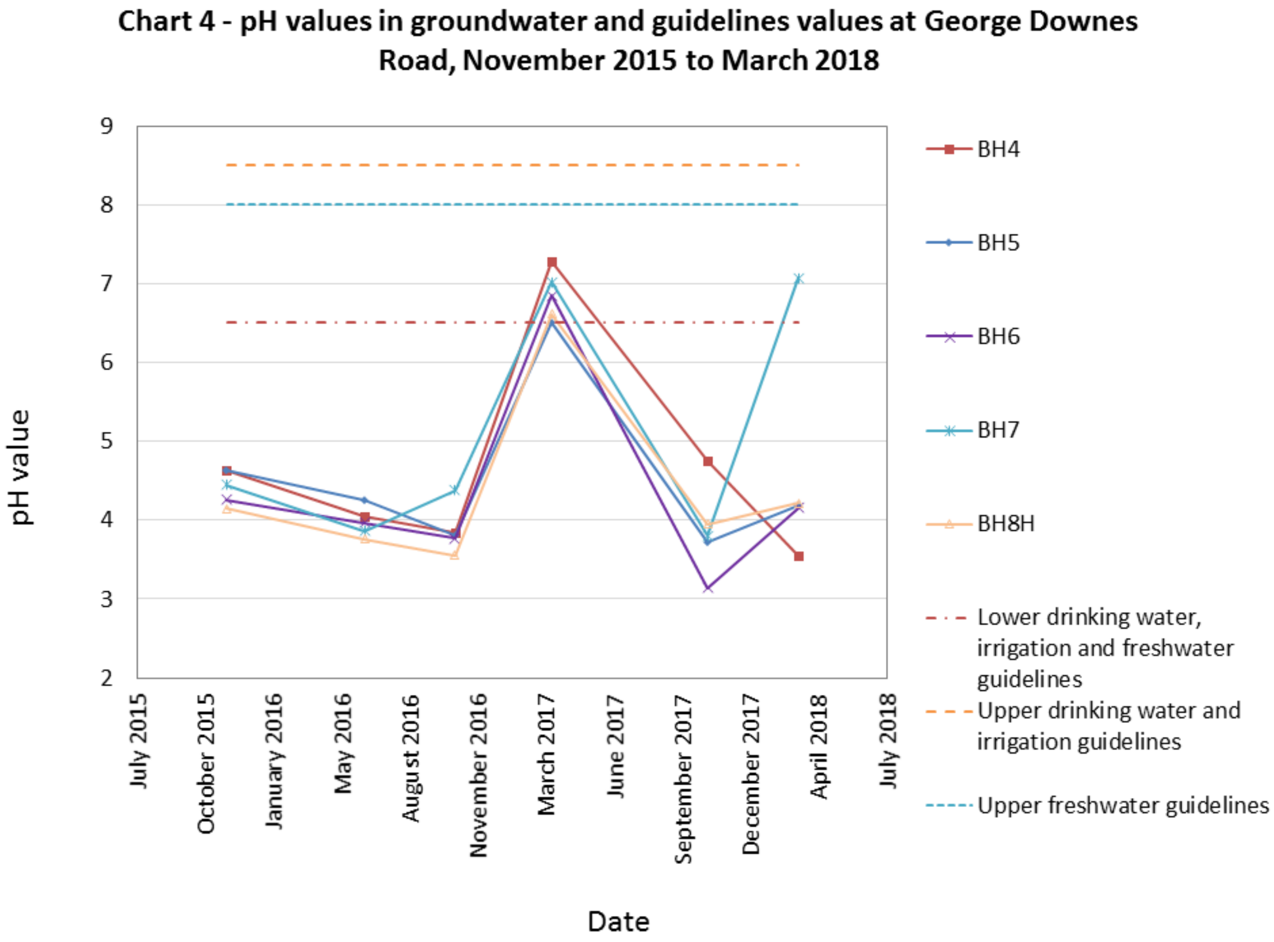


Field pH values generally range between 3.1 and 7.3, and fluctuate between GMEs. Relatively high pH values were measure in March 2017 following heavy rainfalls; the near neutral pHs measured during the March GME indicate significant infiltration of rainwater in the groundwater system. Long-term trends in groundwater elevation and rainfall are presented in Appendix A (Figure 4).

5.2.2 EXCEEDANCES

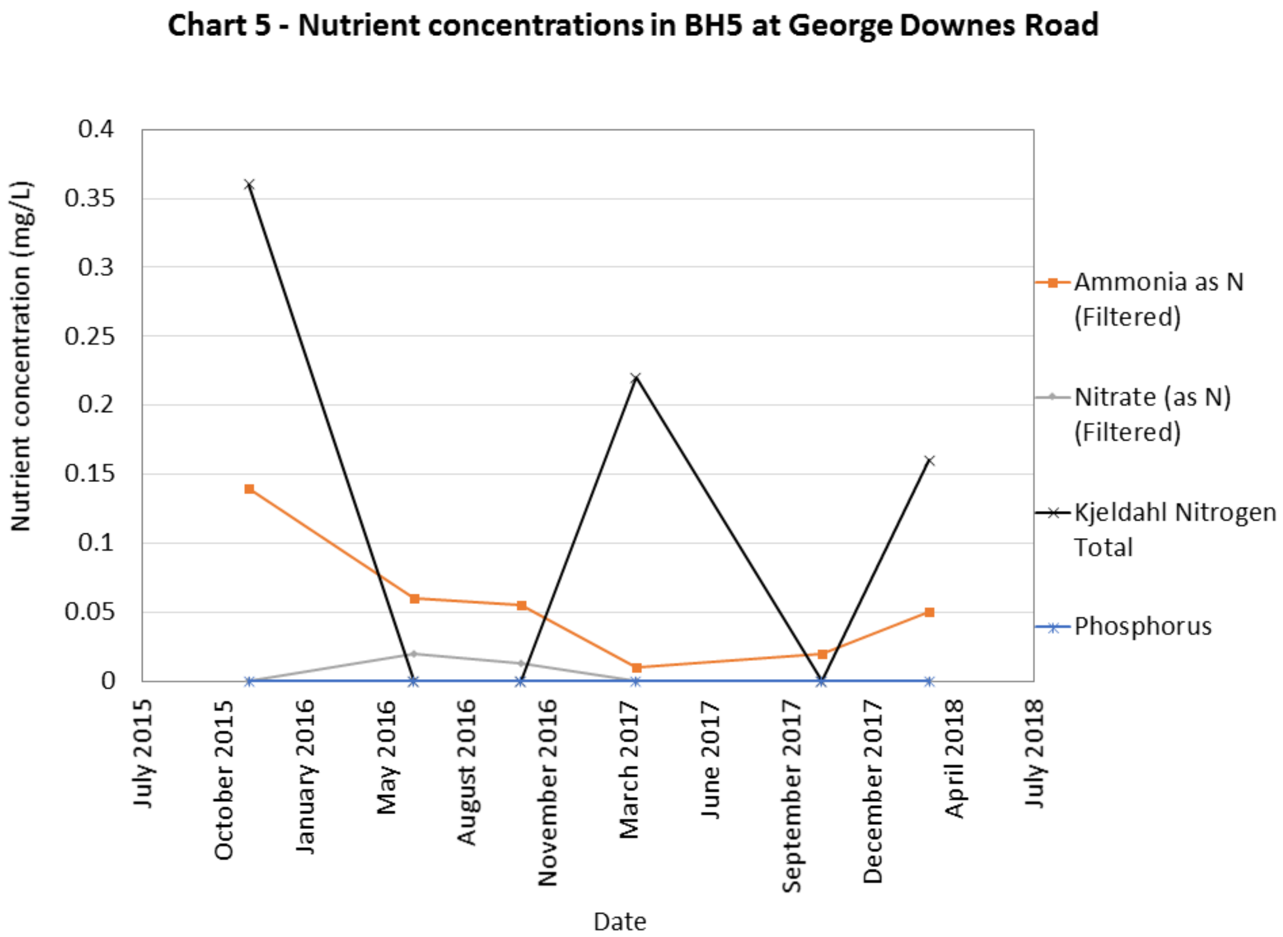
The pH values detected in groundwater from all monitoring wells at George Downes Drive were reported outside of the adopted assessment criteria for drinking water and irrigation use (6.5 to 8.5 pH value) and for protection of freshwater ecosystems (6.5 to 8.0 pH value) in most cases between November 2015 and March 2018. The bands of acceptance (between the lower threshold and upper threshold for acceptable pH) and the groundwater pH values are presented on

Chart 4. The low pHs detected at the George Downes Drive site reflect the acidic nature of groundwater that interacts with the Hawkesbury Sandstone formation.



5.3 NUTRIENTS

Nitrogen and phosphorus are released during the decomposition of organic material, including animal carcasses, they are also agricultural fertilisers. Their presence in groundwater downgradient of the burial pit could potentially indicate migration of leachate. Chart 5 presents the trends in key nutrients in the most down gradient well, BH5. While nitrate (as nitrogen-N) and phosphorous concentrations remained stable between November 2015 and March 2018, total Kjeldahl nitrogen showed fluctuations. Ammonia (as nitrogen-N) concentrations presented a slight decrease over time in well BH5.

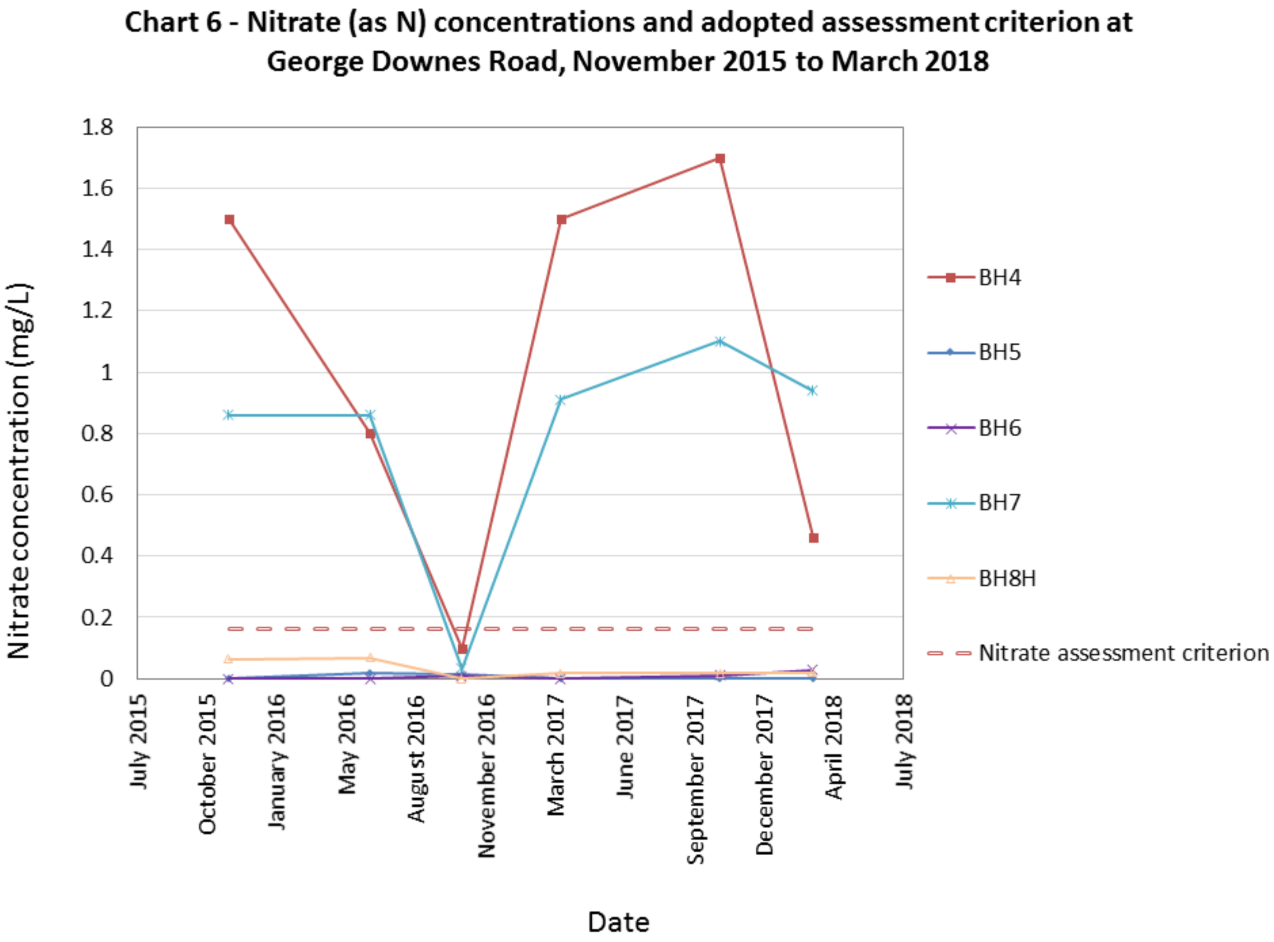


5.3.1 NITRATE

5.3.1.1 TRENDS

Common sources of nitrate in the environment include fertilisers, animal wastes, septic tanks, municipal sewage treatment systems and decaying plant debris. Excess nitrogen within the environment can contribute to eutrophication and algal blooms, leading to oxygen depletion in water. Nitrate can also be an important contaminant in drinking water

Concentrations of nitrate (as N) in groundwater collected form the down gradient well BH5 remained low, below the adopted assessment criterion, and relatively stable between November 2015 and March 2018 (Chart 6). Similar concentration trends were presented by wells BH6 and BH8H. In contrast, nitrate concentrations detected in wells BH4 (thought to be up gradient) and BH7 were high and showed relatively high degree of variations over time, with values below and above the adopted assessment criterion.



5.3.1.2 EXCEEDANCES

Concentrations of nitrate (as N) in groundwater consistently remained above the adopted assessment criterion for the protection of freshwater ecosystems (0.16 mg/L) in up gradient well BH4 and down gradient well BH7, as presented on Chart 6. The only exception was during the GME undertaken in October 2016, when groundwater samples collected from wells BH4 and BH7 showed nitrate (as N) concentrations below the adopted assessment criterion. It is possible the nitrate presence is predominantly due to regional nitrate from agricultural activities rather than leakage from the cell, particularly due to the presence in the (assumed) up-gradient location BH4.

Concentrations of nitrate (as N) in groundwater in wells BH5 (down gradient), BH6 and BH8H were lower than the adopted assessment criterion and, in several cases, below the laboratory limit of reporting (LOR).

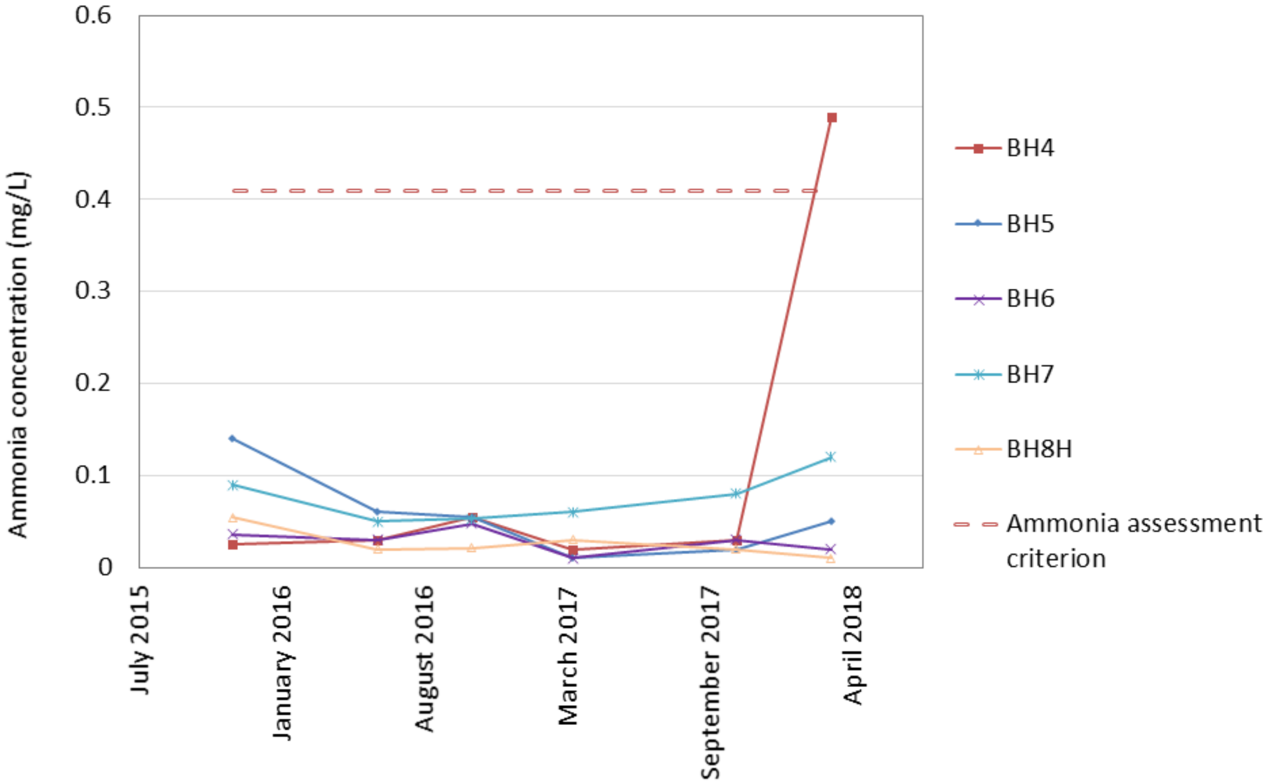
5.3.2 AMMONIA

Ammonia is produced during the decay processes of animal and vegetable matter and by anthropogenic sources such as livestock farming practices and sewage (including septic systems). Ammonia can be toxic to aquatic organisms at varying concentrations, depending on pH conditions. Ammonia is a nutrient and oxidises to nitrate in surface water which can contribute to algal blooms.

5.3.2.1 TRENDS

Concentration of ammonia (as N) in all monitoring wells on the site did not fluctuate significantly between November 2015 and March 2018, generally ranging from values equal to the LOR (0.01 mg/L) to 0.14 mg/L. The only exception was the ammonia (as N) concentration detected in the up gradient well BH4 during the March 2018 GME, which was significantly higher than any other measured concentration and above the assessment criterion of 0.41 mg/L. This should be monitored closely in subsequent rounds, though it is noted that occasional elevated levels of ammonia at this location have occurred in the past (2013). Concentration trends in down gradient well BH5 are presented on Chart 7 and Chart 5.

Chart 7 - Ammonia (as N) concentrations and adopted assessment criterion at George Downes Road, November 2015 to March 2018



5.3.2.2 EXCEEDANCES

The adopted assessment criterion for ammonia of 0.41 mg/L was exceeded only in one case throughout the monitoring period, as shown on Chart 7. In March 2018, the groundwater sample collected from up gradient well BH4 showed an ammonia concentration of 0.49 mg/L. All remaining samples collected between November 2015 and March 2018 presented ammonia concentrations below the laboratory assessment criterion.

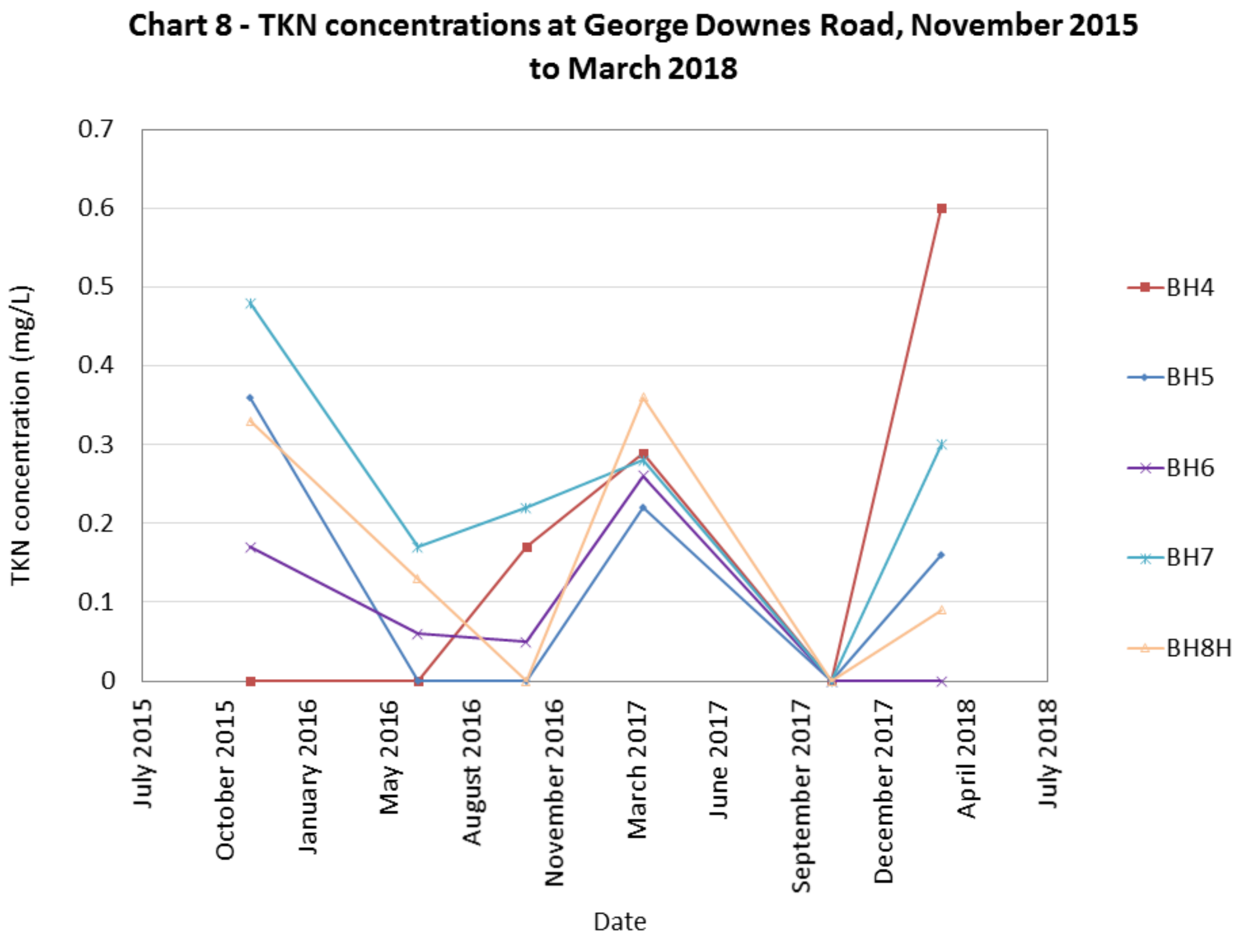
The elevated ammonia (as N) concentration observed in BH4 in March 2018 is considered likely to be indicative of regional sources, e.g. due to the intensive agricultural land use around the Kulnura- Mangrove Mountain locality.

5.3.3 TOTAL KJELDAHL NITROGEN

Total Kjeldahl nitrogen (TKN) is the sum of all organic nitrogen and ammonia in a given groundwater sample.

5.3.3.1 TRENDS

TKN concentrations were similar in all groundwater monitoring wells in the period from November 2015 to March 2018, ranging between the laboratory LOR (0.05 mg/L) and 0.6 mg/L, as presented on Chart 8. The highest TKN concentration was recorded in the groundwater sample collected from BH4 in March 2018. This is possibly a reflection of background elevated nitrogen (in various forms) in BH4.



5.3.3.2 EXCEEDANCES

There are no applicable adopted assessment criteria for TKN.

5.3.4 PHOSPHOROUS

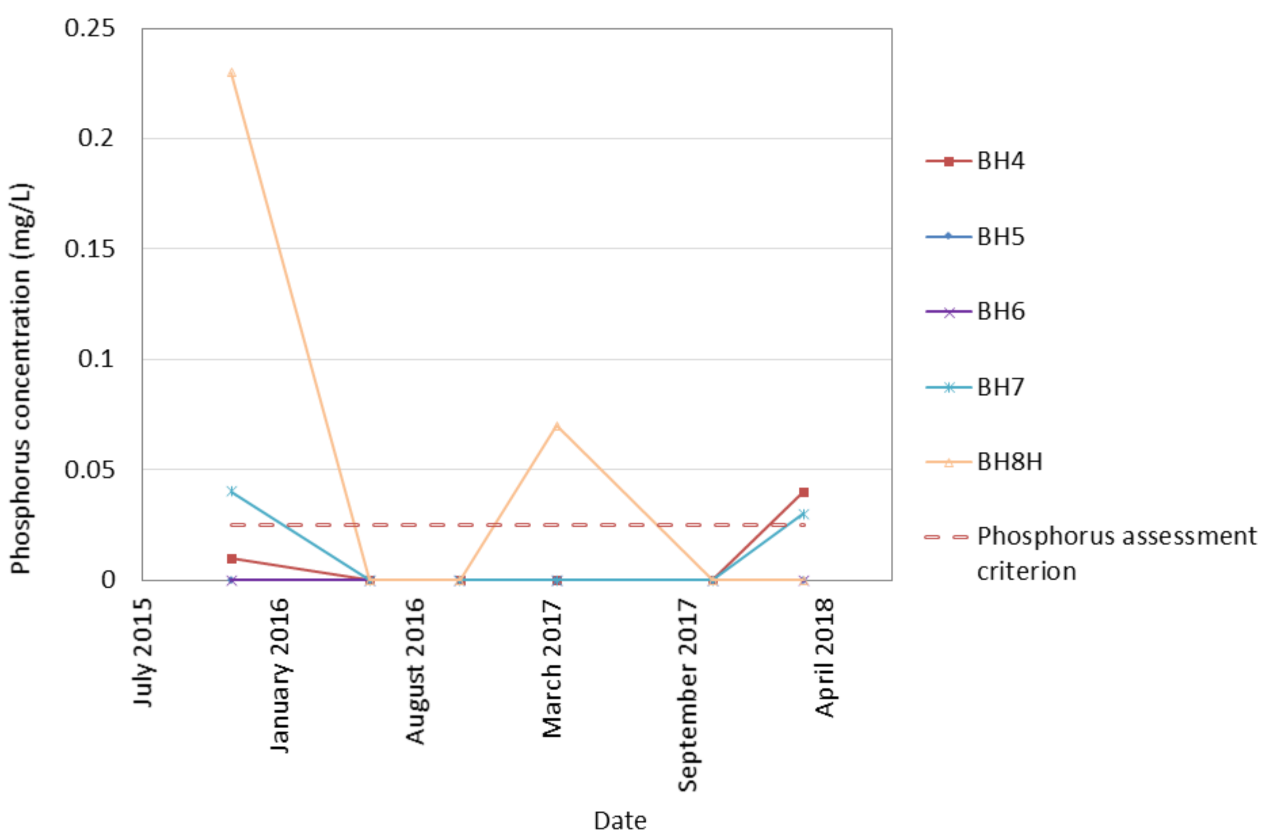
Phosphorus is used in the production of fertilisers. An excess of phosphorus in surface water can contribute to favourable conditions for an algal bloom. Phosphorus binds strongly to iron compounds in soil, and is not generally as mobile as nitrogen in groundwater.

Phosphorus is commonly analysed as soluble reactive phosphorus (which is predominantly orthophosphate) or total phosphorus, which includes organic phosphorus and particulate phosphorus, as well as soluble reactive phosphorus. Total phosphorus has been analysed during this monitoring program.

5.3.4.1 TRENDS

The concentration of total phosphorus in down gradient monitoring well BH5 and cross gradient well BH6 remained below the laboratory LOR (0.01-0.02 mg/L) throughout the monitoring period, as presented in Chart 9. In contrast, groundwater samples collected from the up gradient well BH4, down gradient well BH7 and cross gradient BH8H showed a higher variability, with phosphorus concentrations ranging from values lower than the LOR to 0.23 mg/L. No clear pattern are apparent.

Chart 9 - Phosphorus concentrations and adopted assessment criterion at George Downes Road, November 2015 to March 2018



5.3.4.2 EXCEEDANCES

Total phosphorus has been reported above the adopted assessment criteria for the protection of freshwater aquatic ecosystems in up gradient well BH4 (March 2018), BH7 (November 2015 and March 2018) and BH8H (November 2015 and March 2017) with no apparent pattern to the fluctuation. There are no guidelines established for phosphorus for the protection of human health or aesthetic criteria.

5.4 METALS

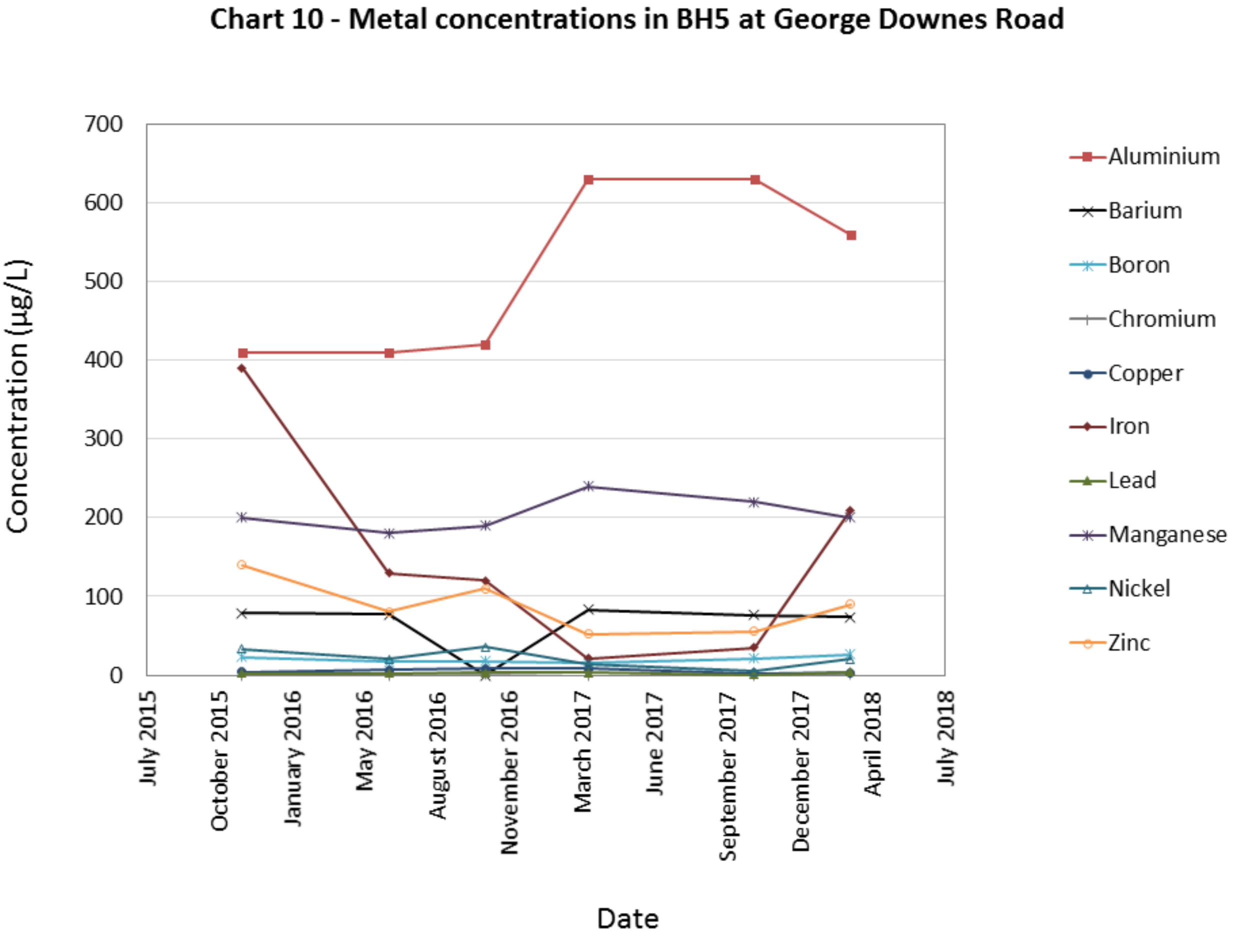
Analysis of heavy metals and metalloids (aluminium, arsenic, barium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc) was undertaken to assess the potential degradation and solubilisation of the metal shipping containers housing the poultry carcasses. Leakage of high nutrient liquid may also potentially interact with sub-surface geology and the geochemistry of the groundwater potentially resulting in changes to soluble metal concentrations.

The trends for the metals and metalloids reported above the laboratory limit of reporting (LOR) are presented below.

5.4.1 TRENDS

Chart 10 presents the trends in metals and metalloids concentrations detected during the six groundwater monitoring events (GMEs) undertaken at the site between November 2015 and March 2018 in down gradient well BH5. Concentrations of arsenic and cadmium are not presented in Chart 10 as they were below the laboratory LOR.

Concentrations of barium, boron, chromium, copper, lead, manganese, nickel and zinc in well BH5 fluctuated slightly between November 2015 and March 2018. An increasing trend was also presented by aluminium concentrations, which rose from about 400 µg/L to 560 throughout the monitoring period. Iron concentrations in down gradient well BH5 were variable and declined from 390 µg/L in November 2015 to 21 µg/L in March 2017, and then rose to 210 µg/L between March 2017 and March 2018.



5.4.2 EXCEEDANCES

Aluminium, chromium, copper, iron, lead, manganese, nickel and zinc were detected exceeding the site investigation levels in one or more of the groundwater samples collected at the George Downes Drive site between November 2015 and March 2018. The adopted investigation level (or assessment criteria) for all metals was the thresholds values for the protection of freshwater aquatic ecosystems with the exception of arsenic, barium, iron and manganese for which the recreational or drinking water guideline were applied.

Aluminium concentrations, presented in Chart 11, have consistently remained above the adopted assessment criterion for freshwater aquatic ecosystems (55 µg/L) in all groundwater monitoring wells on site, except for up gradient well BH4. At the BH4 sampling location, the assessment criterion was exceeded only in the October 2016 GME (80 µg/L).

During all GMEs, the highest concentrations were presented in downgradient wells BH6 and BH5. Considering the natural chemical conditions of the local aquifer, WSP considers the results are likely to be due to the acidity of the local groundwater resulting in greater dissolution of heavy metals from the aquifer matrix. ANZECC (2000) only provides an aluminium criterion for groundwater with a pH greater than 6.5 as there is insufficient data for groundwater with a pH lower than 6.5. The aluminium concentrations also exceeded the aesthetic drinking water guideline criterion of 200 µg/L in BH5, BH6 and BH8H.

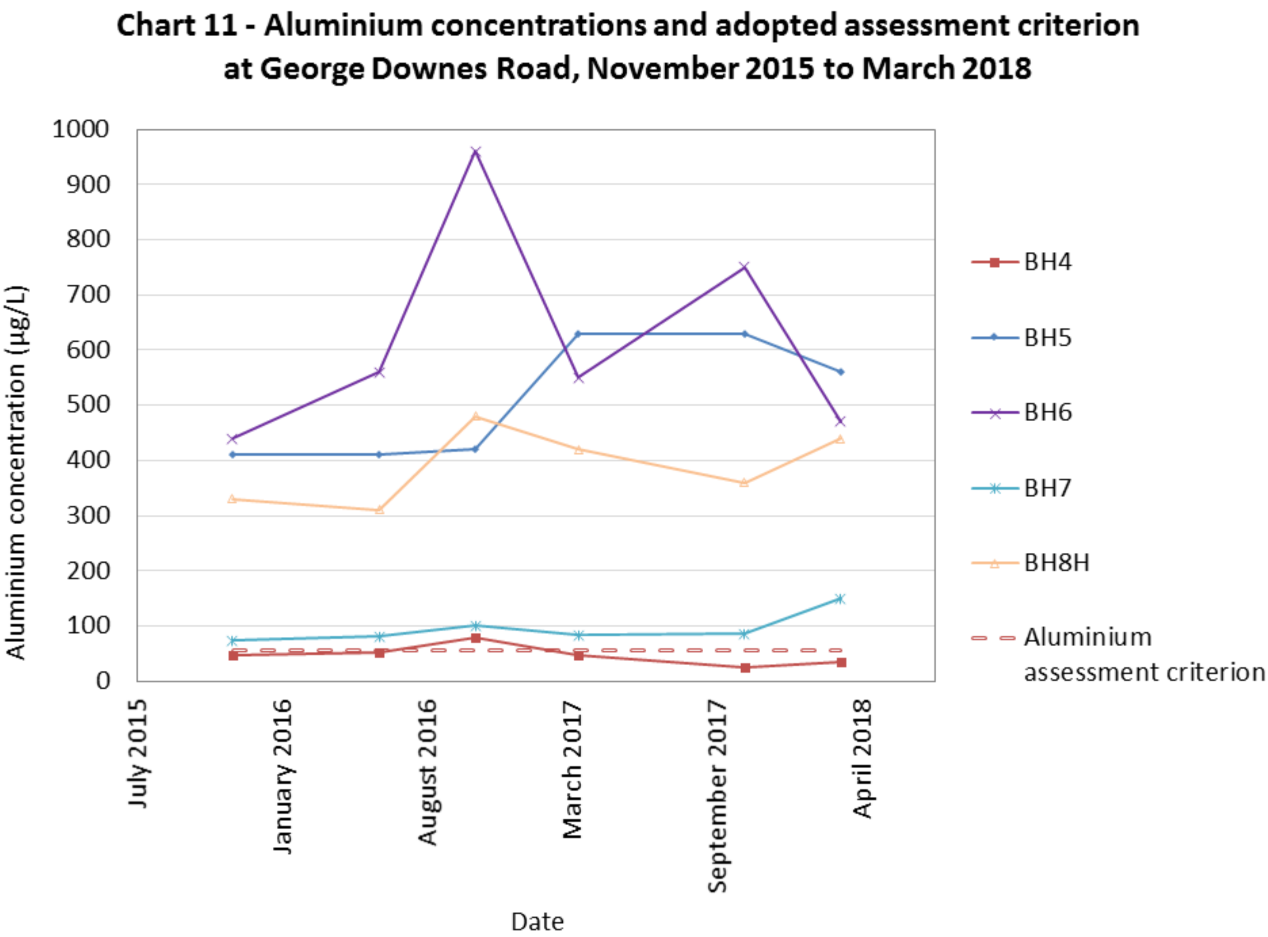
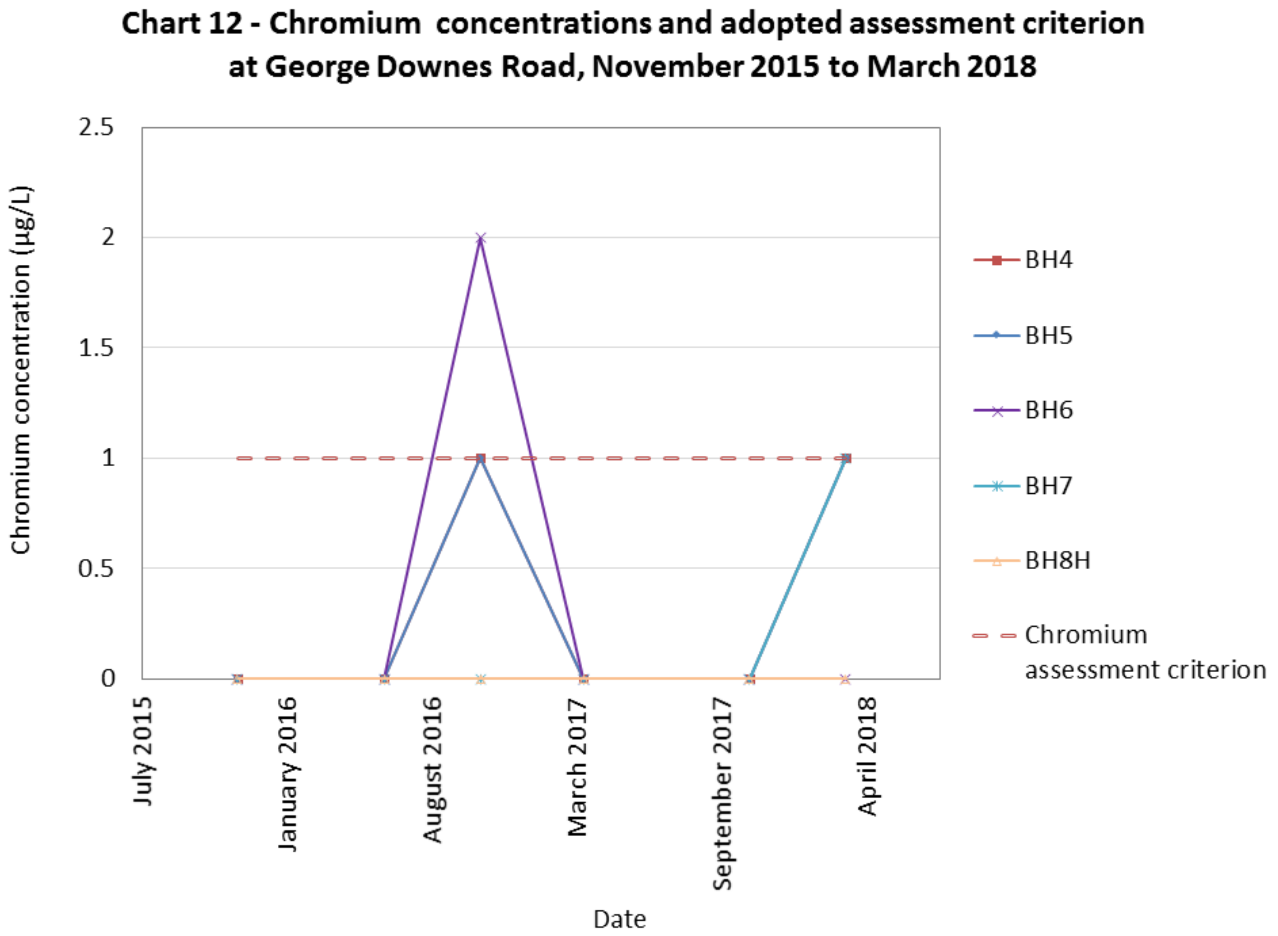
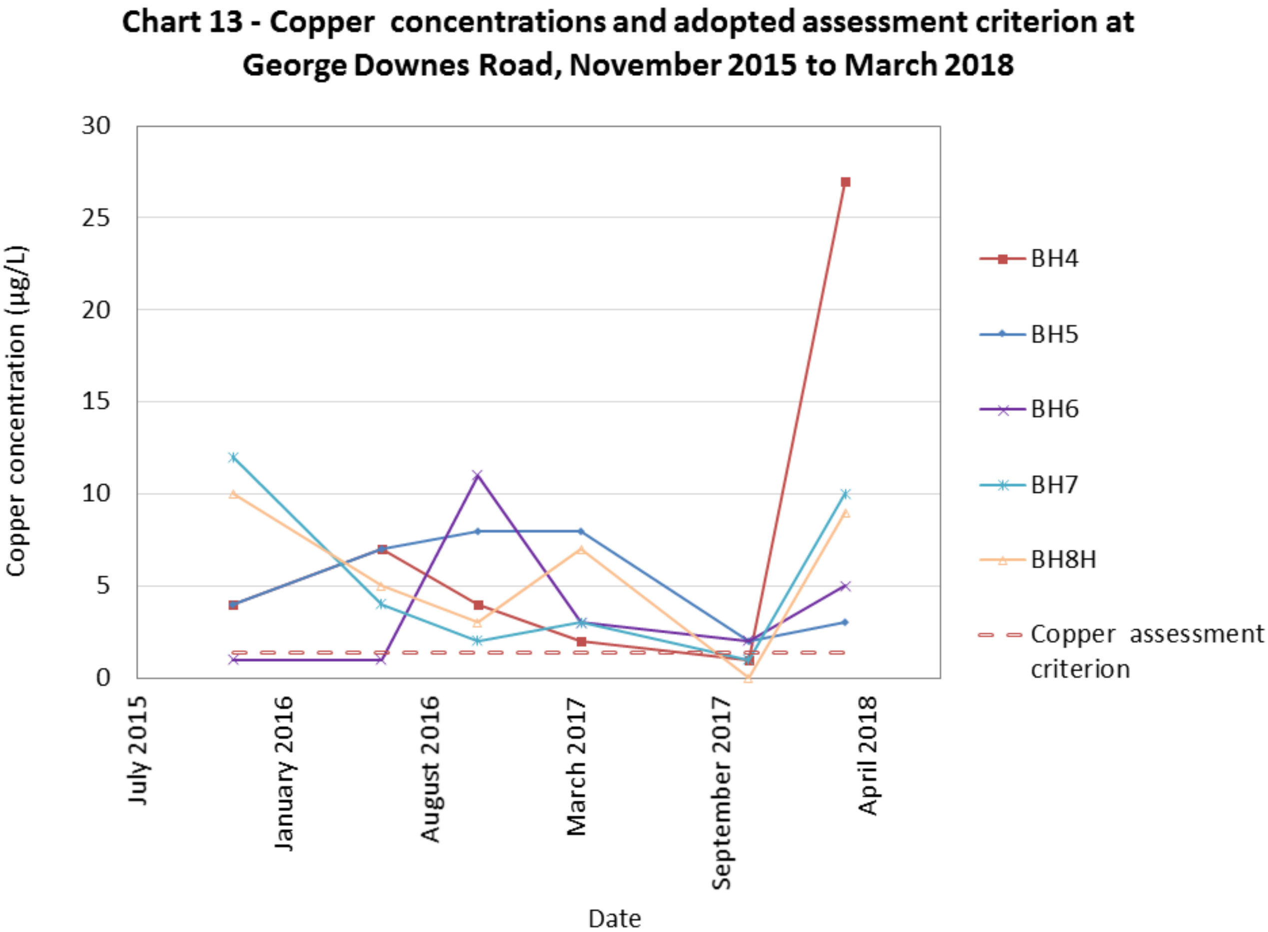


Chart 11 - Aluminium concentrations and adopted assessment criterion at George Downes Road, November 2015 to March 2018
1000
900
800
700
600
500
400
300
200
100
0
Aluminium concentration (µg/L)
July 2015
January 2016
August 2016
March 2017
September 2017
April 2018
Date
BH4
BH5
BH6
BH7
BH8H
Aluminium assessment criterion

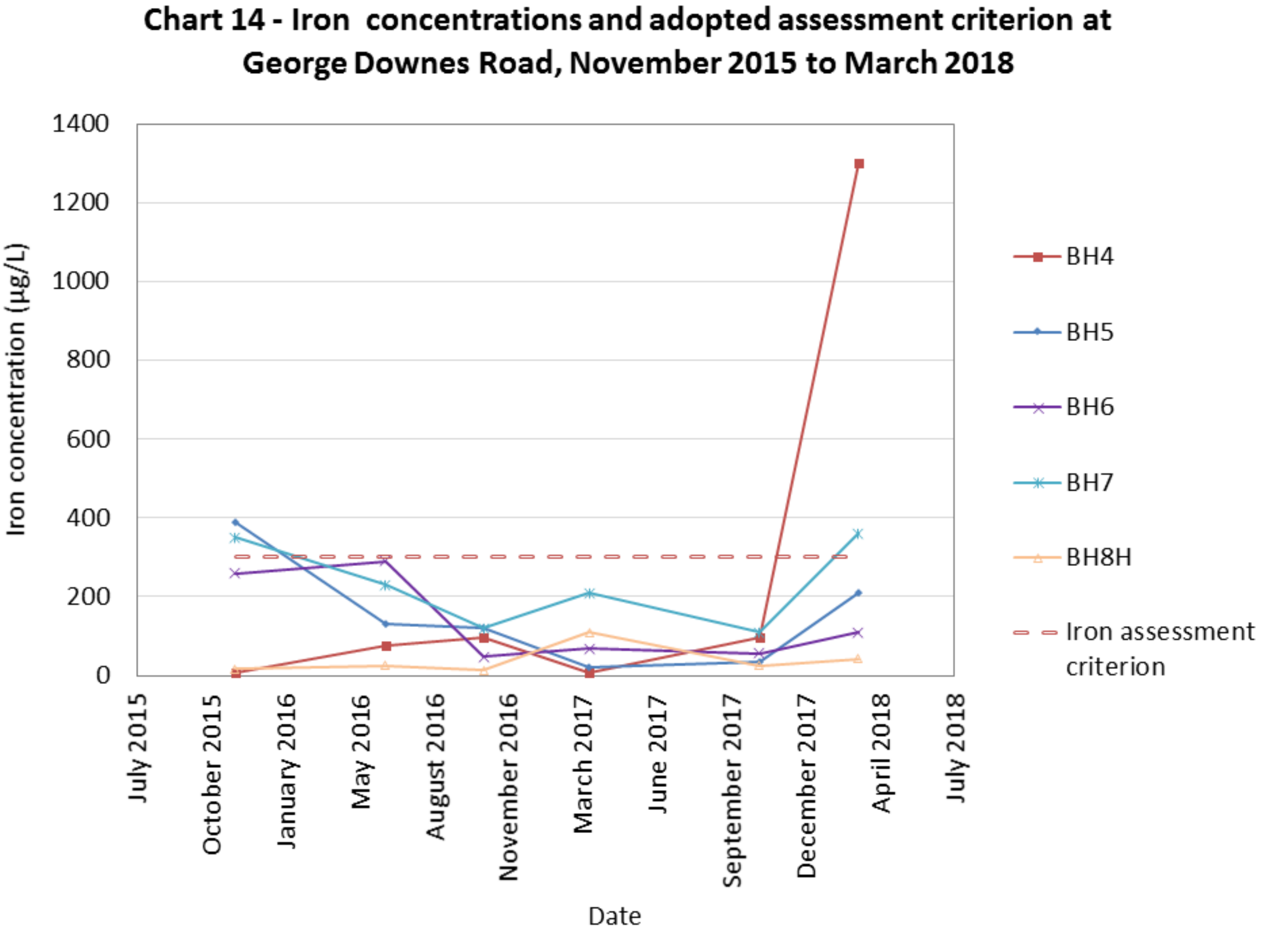
Concentrations of chromium were only reported above the adopted assessment criterion (1 µg/L) in well BH6 in October 2016 (2 µg/L), as presented on Chart 12. These sporadic chromium results are unlikely to be due to leakage from the cell but more likely natural variability.



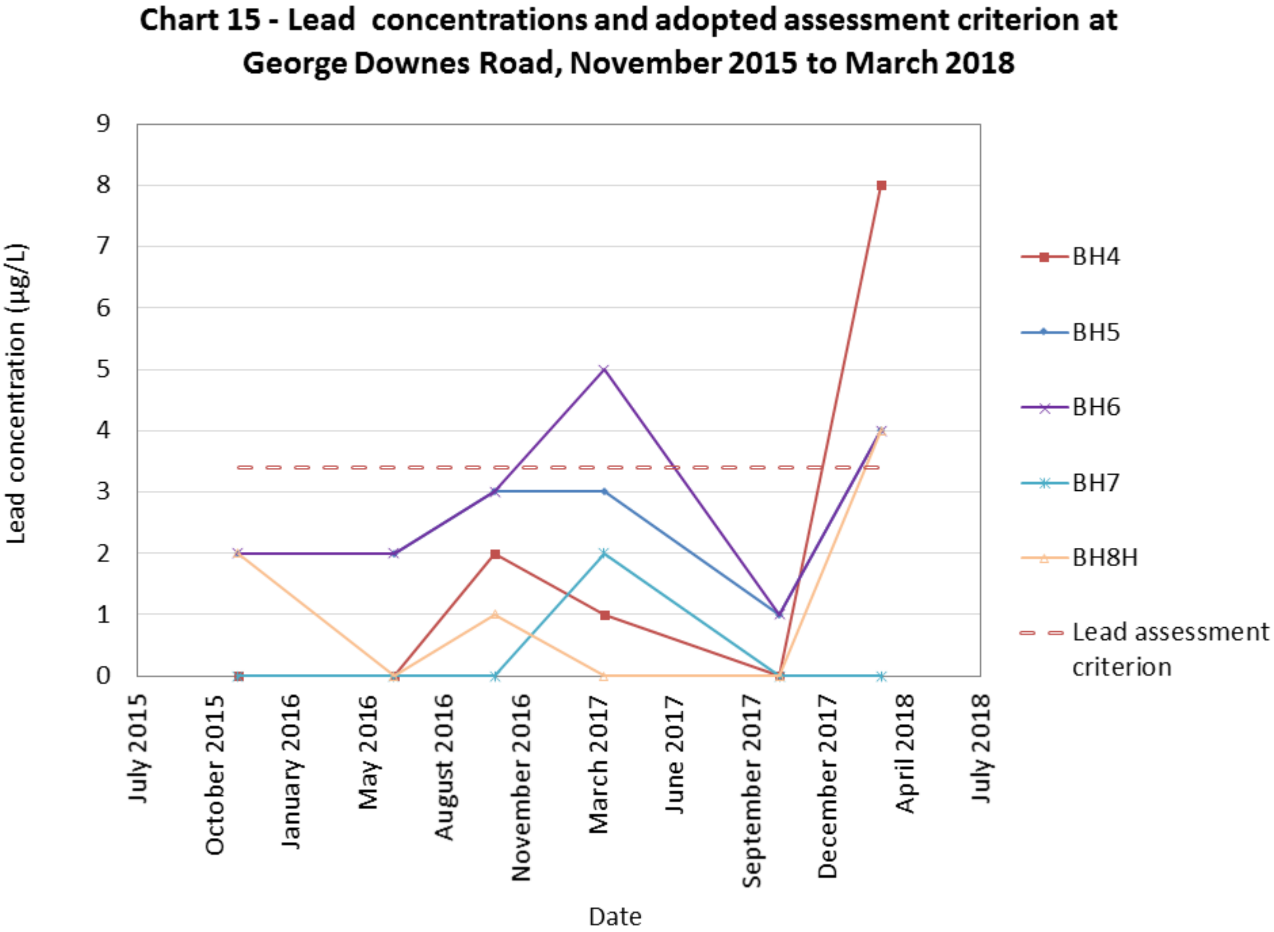
Copper concentrations were generally reported at levels approaching or above the adopted assessment criterion of 1.4 µg/L in most occasions since November 2015. The concentrations of copper on the site were considered representative of background levels.



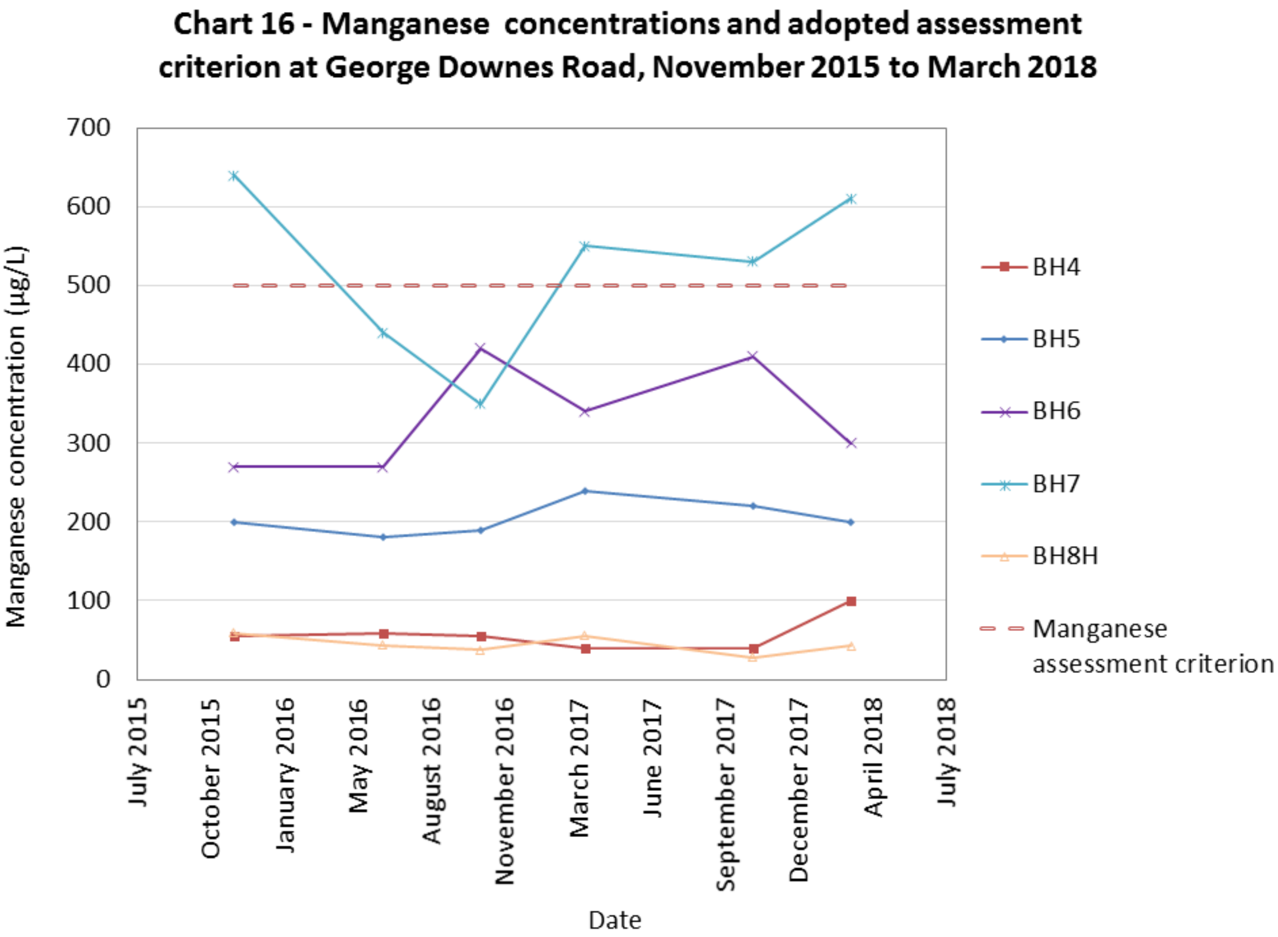
Iron concentrations in groundwater samples collected from the George Downes Drive site were normally lower than the recreational assessment criterion of 300 µg/L during the monitoring period. A total of four exceedances occurred in November 2015 (BH5 and BH7) and in March 2018 (BH4 and BH7), with the highest concentration presented by up gradient well BH4 (1,300 µg/L). Hence, the iron concentrations above the assessment criterion are likely due to naturally high iron levels in the local aquifer under the low pH conditions.



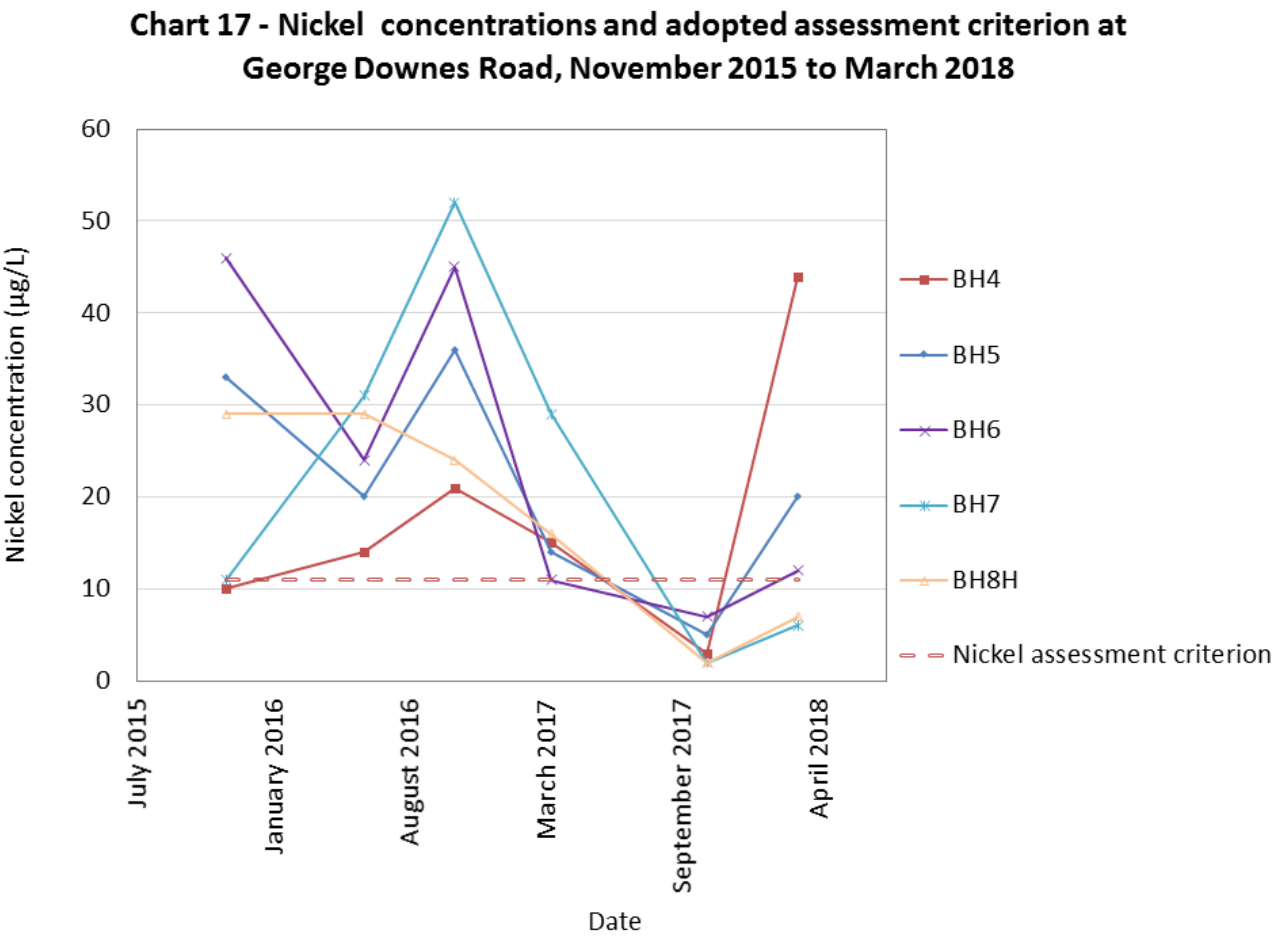
Concentrations of lead were generally below the adopted assessment criterion (3.4 µg/L), as presented in Chart 15. The only exceptions were the groundwater samples collected form BH6 in March 2016, and BH4 (up gradient), BH6 and BH8 in March 2018. Up gradient well BH4 presented the highest lead concentration at the site, indicating that relatively high levels of lead are representative of background levels.



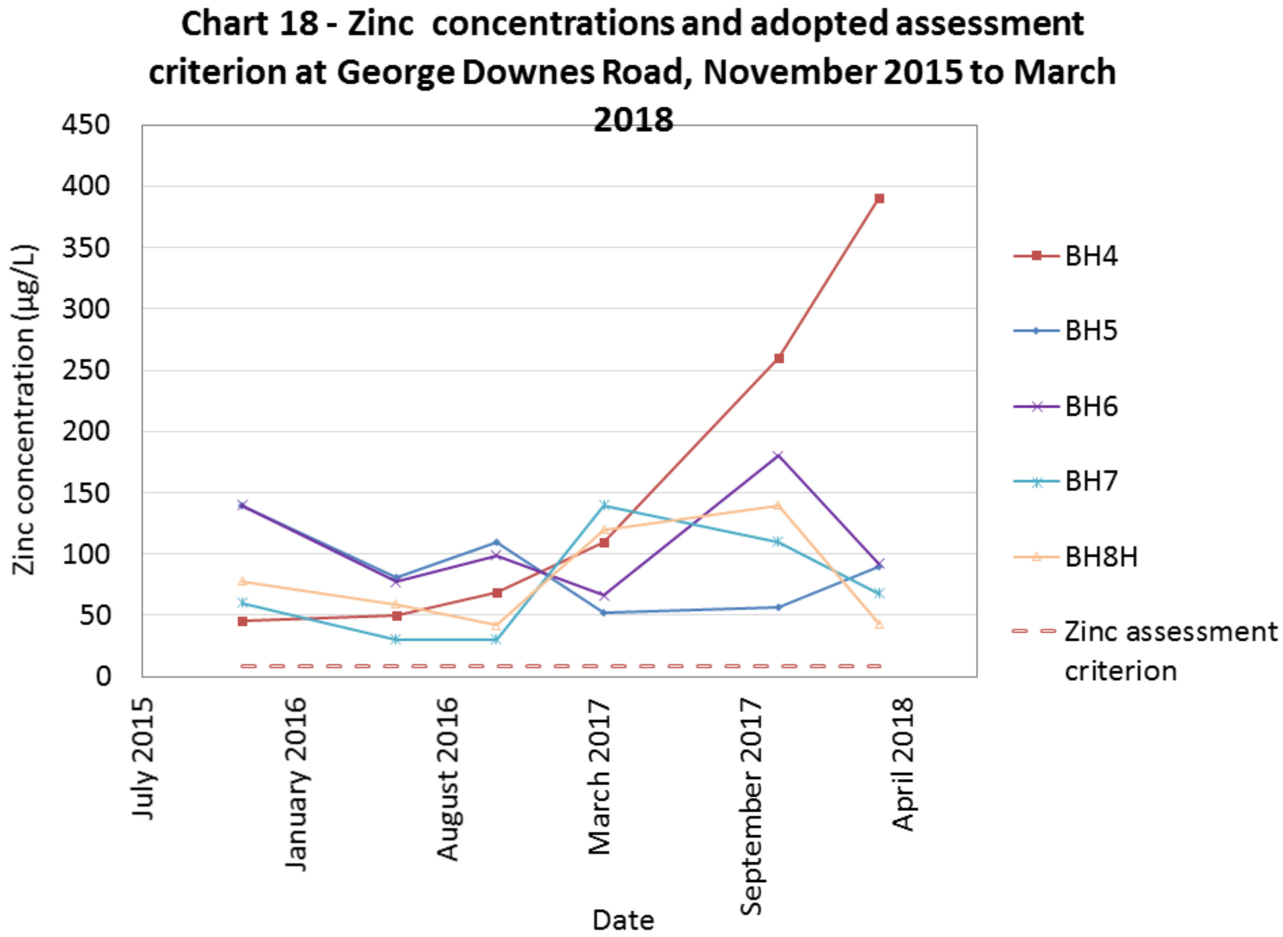
Manganese concentrations, presented in Chart 16, exceeded the drinking water assessment criterion of 500 µg/L only in downgradient well BH7, in four of the six groundwater monitoring events. The remaining up gradient and downgradient wells showed manganese levels below the assessment criterion. It is presumed the levels observed are likely to be due to natural sources under the low pH conditions.



Concentrations of nickel were generally reported at levels above the adopted assessment criterion of 11 µg/L, and above the Australian drinking water guideline level (20 µg/L), in most wells since November 2015 (Chart 17). An exception was the GME undertaken in November 2017, during which all wells showed nickel concentrations below the assessment criteria. Up gradient well BH4 has historically had amongst the highest nickel concentrations on the site. Thus, the concentrations of nickel on the site were considered representative of the background levels under low pH conditions.



Zinc levels have remained above the adopted assessment criterion of 8 µg/L in both up and down gradient monitoring wells between November 2015 and March 2018. While zinc concentrations remained relatively stable in down and cross gradient wells BH5, BH6, BH7 and BH9H, they gradually increased in up gradient well BH4 from 45 µg/L to 390 µg/L. The high zinc concentrations on the site were considered generally representative of background levels, though the rising trend in BH4 warrants ongoing assessment. Nevertheless, it is noted that zinc in BH4 has fluctuated up to similar levels in the past (March 2014). There is no established health guideline level for zinc in the Australian Drinking Water Guidelines (2000).



5.4.3 SUMMARY OF EVALUATION OF TRENDS IN METAL CONCENTRATION

The monitoring of metals showed considerable variability in concentrations and several exceedances of water quality criteria. Exceedances may be due to the natural acidic groundwater conditions typical of the sandstone aquifers in the Sydney and Central Coast regions. Furthermore, the aquifer in the Mangrove Mountain district is known to have acidic pH. Groundwater with an acidity around pH 4 to 4.5, interacting with the geological profile (i.e. soil and bedrock), tends to dissolve and mobilise metals. This process is likely to produce groundwater with naturally high metal concentrations.

The groundwater monitoring results for the metals and metalloids at the George Downs Drive site do not currently indicate that the containment cell is leaking.

6 SITE MAINTENANCE WORK SUMMARY

Amendment of the pit surface with clay and excavated natural material was recently completed at the George Downes Drive poultry burial pit site. Cap enhancement (i.e. strip of the vegetation and of the surface top-soil layers of the burial pit, and subsequent installation of dual High Density Polyethylene (HDPL)/Geocomposite Clay Layer (GCL) upper liner with sub-surface methane drainage/venting) will be guided by the planning and implementation of Stage 3 of the Bloodtree Road burial pit renovation works (proposed at that site for 2018/19).

7 CONCLUSIONS

Groundwater monitoring from events 18 to 23, overall, were generally consistent. Monitoring of indicator parameters in groundwater showed no evidence of any significant leakage from the burial pit. Minor nutrient rises in BH7, along with mounding, may indicate some localised leakage. Nutrient and heavy metals have fluctuated and generally risen during the reporting period in BH4, which is some distance from the cell and in a location historically considered to be background. These relationships warrant ongoing investigation, though it is noted that similar rises in nutrients and metals in BH4 have occurred in the past before returning to more typical levels.

REFERENCES

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- Australian Government – National Health and Medical Research Council (2011; revised March 2015) Australian Drinking Water Guidelines.
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- National Environment Protection Council (NEPC) (2013) National Environmental Protection Measure (NEPM) (Assessment of Site Contamination).
- Parsons Brinckerhoff (2013) Sampling and Analysis Quality Plan, Mangrove Mountain Groundwater Monitoring Project 2012 – 2015.
- WSP (2017 d) Groundwater monitoring event 21, Mangrove Mountain poultry burial sites, dated September 2017 – March 2017 GME.
- WSP (2018a) Groundwater monitoring event 22, Mangrove Mountain poultry burial sites, dated March 2018 – November 2017 GME.
- WSP (2018b) Groundwater monitoring event 23, Mangrove Mountain poultry burial sites, dated July 2018 (draft) – March 2018 GME.
- WSP | Parsons Brinckerhoff (2017a) Groundwater monitoring event 18, Mangrove Mountain poultry burial sites, dated 4 January 2017 – November 2015 GME – Rev. C.
- WSP | Parsons Brinckerhoff (2017b) Groundwater monitoring event 19, Mangrove Mountain poultry burial sites, dated 20 February 2017 – June 2016 GME.
- WSP | Parsons Brinckerhoff (2017c) Groundwater monitoring event 20, Mangrove Mountain poultry burial sites, dated 20 February 2017 – October 2016 GME.

APPENDIX A

FIGURES

Figure 1

Mangrove Mountain Groundwater Monitoring Locations

0 1 km

Approximate site location

Mangrove Mountain Groundwater Monitoring Project
Site summary status – George Downes Drive

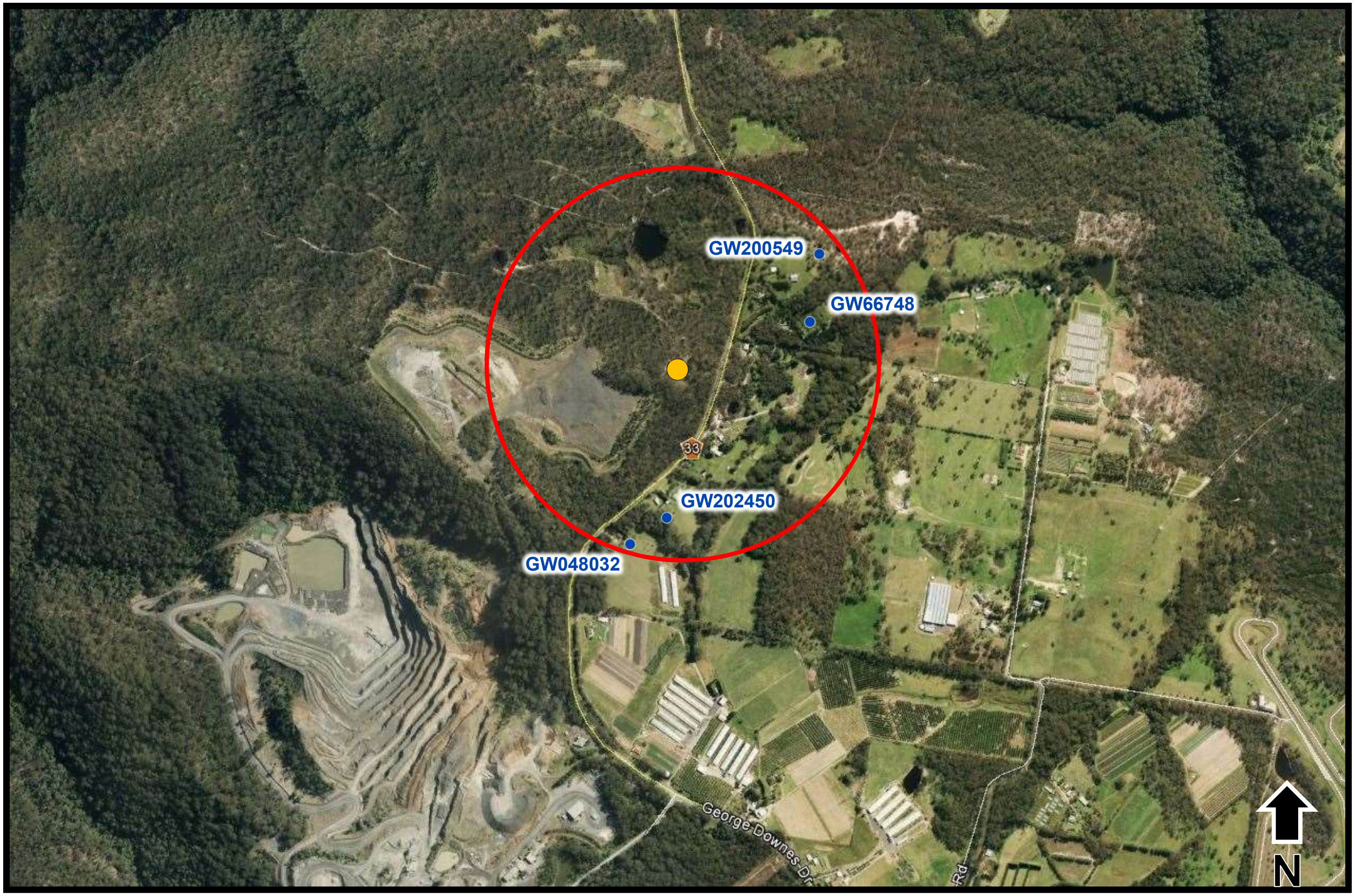

Figure 2

Registered Groundwater Bores-George Downes Drive, Mangrove Mountain

Mangrove Mountain Groundwater Monitoring Project

Poultry burial site

Registered groundwater bore

500 m buffer

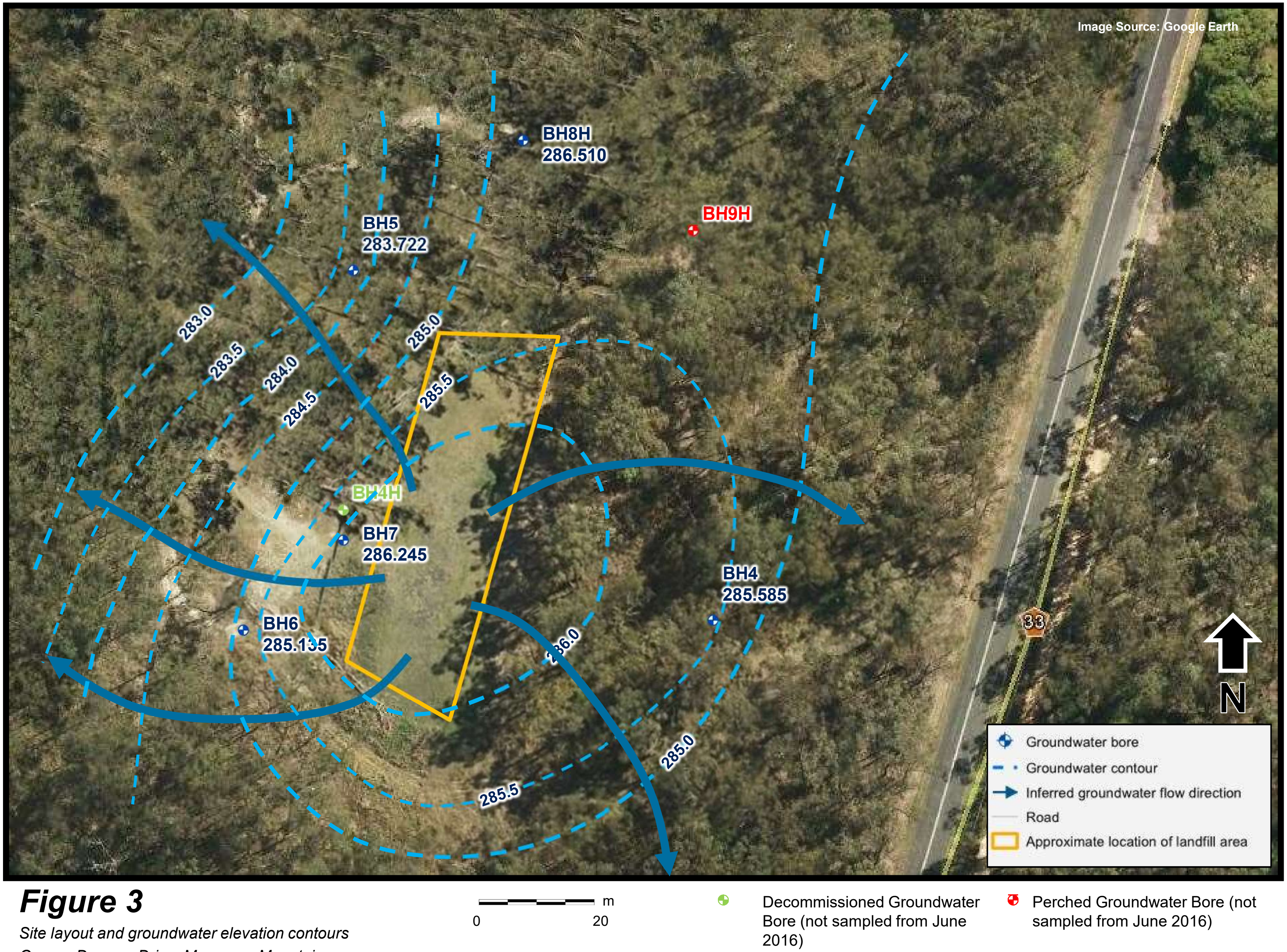

Figure 3

Site layout and groundwater elevation contours
George Downes Drive, Mangrove Mountain

Mangrove Mountain Groundwater Monitoring Project
Groundwater Monitoring Event 23 (March 2018)

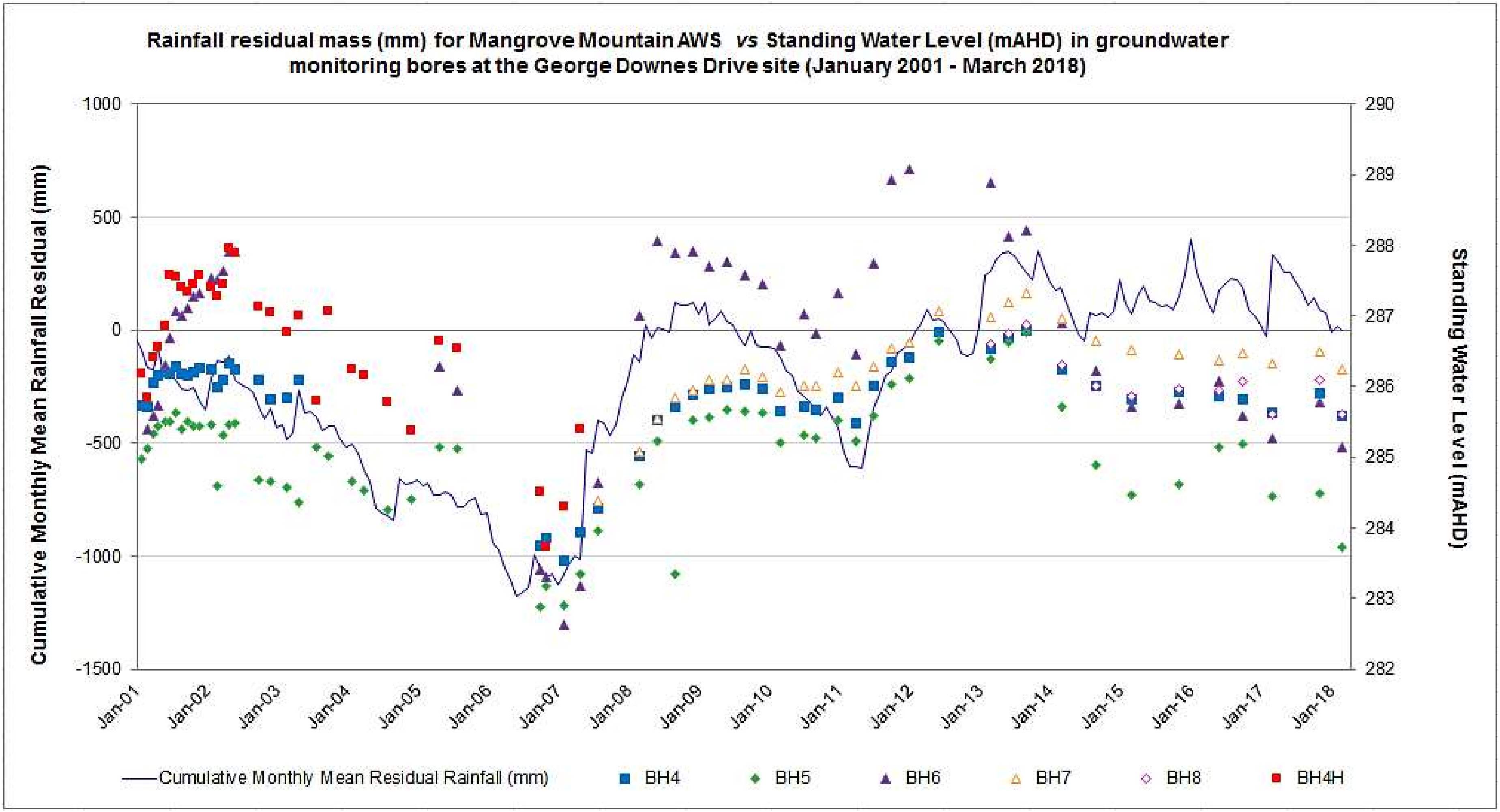

Figure 4: Rainfall residual mass (mm; Jan 2001 – Mar 2018) vs Standing Water Level (mAHD) in groundwater monitoring bores at the George Downes Drive poultry burial site (January 2001 – March 2018)[1] (Average monthly rainfall (mm) = Jan 2001 – Mar 2018 @ Mangrove Mountain AWS

[1]David, K., Liu, T., and David, V. (2014) Use of several different methods for characterising a fractured rock aquifer, case study Kempfield, New South Wales, Australia, pages 307-328, in Fractured Rock Hydrogeology, International Association of Hydrogeologists Selected Papers 20, J.M. Sharp (ed.)(2014) CRC Press, Taylor & Francis Group, LLC, Boca Raton, Florida.