

REPORT | 2023 ANNUAL ENVIRONMENTAL REVIEW

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APPENDIX A: ANNUAL AIR QUALITY REVIEW

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HUNTER VALLEY OPERATIONS ANNUAL DATA REVIEW 2023

Hunter Valley Operations

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Prepared by Todoroski Air Sciences Pty Ltd Suite 2B, 14 Glen Street Eastwood, NSW 2122 Phone: (02) 9874 2123 Fax: (02) 9874 2125 Email: info@airsciences.com.au



HUNTER VALLEY OPERATIONS ANNUAL DATA REVIEW 2023

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1 INTRODUCTION

Todoroski Air Sciences have conducted an annual review of the 2023 measured dust levels at monitors which are part of the Hunter Valley Operations (HVO) North and South air quality monitoring network. Elevated short term (i.e. 24-hour average) levels are investigated routinely throughout the year, hence the focus of this review is to present and assess any elevated annual average readings recorded in 2023.

This investigation has analysed the following elevated levels in detail:

- An annual average deposited dust level of 4.8g/m²/month recorded at the DL30 deposited dust gauge monitor;
- An annual average deposited dust level of 9.6g/m²/month recorded at the Warkworth deposited dust gauge monitor;
- + An annual average PM_{2.5} level of 11.1µg/m³ recorded at the Maison Dieu HVAS monitor;
- + An annual average PM_{2.5} level of 13.3μg/m³ recorded at the Kilburnie South HVAS monitor;
- An annual average PM₁₀ level of 32.5µg/m³ recorded at the Warkworth TEOM monitor;
- + An annual average PM₁₀ level of 31.7µg/m³ recorded at the Gliding Club HVAS monitor; and,
- + An annual average TSP level of 130.8μg/m³ recorded at the Warkworth HVAS monitor.

It is noteworthy that the criteria for HVO North differ to those for HVO South. As outlined below, HVO South has more stringent criteria for some pollutants and averaging periods. This arises due to the criteria applicable to new or modified projects becoming more stringent over time.

2 ANNUAL AIR QUALITY CRITERIA

2.1 HVO North

2.1.1 Air Quality Criteria

As per HVO North consent DA 450-10-2003 "Except for the air-affected land referred to in Table 1, the Applicant must ensure that all reasonable and feasible avoidance and mitigation measures are employed so that the particulate matter emissions generated by the development do not exceed the criteria listed in Tables 2, 3 or 4 at any residence on privately-owned land or on more than 25 percent of any privately-owned land. In this condition 'reasonable and feasible avoidance and mitigation measures' includes, but is not limited to, the operational requirements in Condition 5 of Schedule 4 and the requirements in Conditions 5 and 6 of Schedule 4 to develop and implement a real-time air quality management system that ensures effective operational responses to the risks of exceedance of the criteria."

The criteria from Tables 2 to 4 as per the HVO North consent DA 450-10-2003 are set out below:

Table 2: Long term criteria for particulate matter			
Pollutant	Averaging period	dCriterion	
Total suspended particulate (TSP) matter	Annual	^α 90 μg/m³	
Particulate matter < 10 μ m (PM ₁₀)	Annual	^α 30 μg/m³	

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources) ^d Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed to by the Secretary.

Table 3: Short term criteria for particulate matter

Pollutant	Averaging period	dCriterion
Particulate matter < 10 μ m (PM ₁₀)	24 hour	°50 μg/m³

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources) ^d Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed to by the Secretary.

Table 4: Long term criteria for deposited dust

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
^c Deposited dust	Annual	^b 2 g/m²/month	°4 g/m²/month

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to other sources) ^b Incremental impact (i.e. incremental increase in concentrations due to the development on its own)

^c Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method

When the measured cumulative annual average deposited dust level at compliance monitors is below the criterion of $4g/m^2/m$ onth in Table 4 it is inferred that compliance is achieved. If this criterion is exceeded, the applicant must demonstrate compliance with the maximum increase in the deposited dust level of $2g/m^2/m$ onth.

2.1.2 Air Quality Acquisition Criteria

"If particulate matter emissions generated by the development exceed the criteria in Tables 5, 6 or 7 on a systemic basis at any residence on privately-owned land or on more than 25 percent of any privately-owned land, then upon receiving a written request for acquisition from the landowner the Applicant must acquire the land in accordance with the procedures in Conditions 7 and 8 of Schedule 5."

Table 5: Long term acquisition criteria for particulate matter			
Pollutant	Averaging period	dCriterion	
Total suspended particulate (TSP) matter	Annual	^α 90 μg/m³	
Particulate matter < 10 μm (PM ₁₀)	Annual	^α 30 μg/m ³	

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources) ^d Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed to by the Secretary.

Table 6: Short term acquisition criteria for particulate matter

Pollutant	Averaging period	^d Criterion
Particulate matter < 10 μ m (PM ₁₀)	24 hour	²150 μg/m³
Particulate matter < 10 μm (PM ₁₀)	24 hour	^b 50 μg/m³

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources) ^b Incremental impact (i.e. incremental increase in concentrations due to the development on its own)

^d Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed to by the Secretary.

Table 7: Long term acquisition criteria for deposited dust			
Pollutant Averaging period		Maximum increase in	Maximum total deposited
Fonatant	Poliutunt Averuging periou	deposited dust level	dust level
^c Deposited dust	Annual	^b 2 g/m²/month	°4 g/m²/month

^a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to other sources) ^b Incremental impact (i.e. incremental increase in concentrations due to the development on its own)

^c Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method

When the measured cumulative annual average deposited dust level at compliance monitors is below the criterion of 4g/m²/month in Table 4 it is inferred that compliance is achieved. If this criterion is exceeded, the applicant must demonstrate compliance with the maximum increase in the deposited dust level of 2g/m²/month.

2.2 HVO South

2.2.1 Air Quality Criteria

As per HVO South consent PA 06_0261 "The Proponent must ensure that all reasonable and feasible avoidance and mitigation measures are employed so that particulate matter emissions generated by the project do not exceed the air quality impact assessment criteria listed in Table 8 at any residence on privately-owned land, the Hunter Valley Gliding Club (when in use) or on more than 25 percent of any privately-owned land."

Pollutant	Averaging period	^d Criterion
Particulate matter < 10 μ m (PM10)	Annual	^{a,c} 25 μg/m³
	24 hour	^b 50 μg/m³
Particulate matter < 2.5 μm (PM _{2.5})	Annual	^{a,c} 8 μg/m³
	24 hour	^b 25 μg/m³
Total suspended particulate (TSP) matter	Annual	^{a,c} 90 μg/m³

Air quality impacts at HVGC are to be assessed in the immediate vicinity of its residential facilities and/or clubhouse. Air quality limits are only applicable during times of use that have been notified by HVGC to the Proponent.

^a Total impact (i.e. incremental increase in concentrations due to the project plus background concentrations due to all other sources).

^b Incremental impact (i.e. incremental increase in concentrations due to the project on its own).

^c Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed to by the Secretary.

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"However, if the Proponent has a written negotiated air quality agreement with any landowner or HVGC to exceed the air quality limits in Table 8 and a copy of this agreement has been forwarded to the Department and EPA, then the Proponent may exceed the air quality limits in Table 8 in accordance with the negotiated air quality agreement."

2.3 Air Quality Criteria Summary

The monitoring locations and annual average criteria for HVO North and HVO South set out in the relevant approvals are presented in **Table 2-1**.

Table 2-1: Annual air quality criteria					
Location	HVO	North	HVO South		
	Deposited Dust Ga	uges (g/m²/month)			
D112*	-	-	-		
D118	2 ¹	4 ²	-		
D119	2 ¹	4 ²	-		
D122	2 ¹	4 ²	-		
DL14	2 ¹	4 ²	-		
DL2*	-	-	-		
DL21	2 ¹	4 ²	-		
DL22	2 ¹	4 ²	-		
DL30	2 ¹	4 ²	-		
Knodlers Lane	2 ¹	4 ²	-		
Warkworth	2 ¹	4 ²	-		
	PM ₁₀ TEO	Μ (µg/m³)			
Wandewoi*	3	0	25		
Golden Highway*		-	-		
Howick*	Howick*				
Knodlers Lane		-	25		
Warkworth		-	25		
Jerrys Plains	3	0	25		
Maison Dieu		-	25		
	PM ₁₀ HVA	.S (μg/m³)			
Cheshunt East	3	0	-		
Gliding Club		-	25		
Long Point		-	25		
Kilburnie South	3	0	25		
	PM _{2.5} HVA	\S (μg/m³)			
Maison Dieu		-	8		
Kilburnie South		-	8		
TSP HVAS (μg/m³)					
Cheshunt East	9	0	-		
Warkworth	-		90		
Wandewoi*		-	-		
Maison Dieu		-	90		
Long Point		-	90		
Knodlers Lane		-	90		
Kilburnie South	9	0	90		

¹ Maximum increase in deposited dust level, ² Maximum total deposited dust level

*Per HVO's Air Quality Management Plan Table 5: HVO Air Quality Monitoring – Planning Approval Compliance Assessment, D112, DL2, Golden Highway and Howick are not compliance monitors. D112, DL2 and Wandewoi are used as representative monitoring locations for mine-owned land.

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2.4 Deposited Dust Data

Table 2-2 and Figure 2-1 summarise the HVO deposited dust monitoring data for the 2023 period.

The DL30 and Warkworth monitors recorded a total annual average level above the criterion of 4g/m²/month.

Month	D112	D118	D119	D122	DL14	DL2	DL21	DL22	DL30	Knodlers Lane	Warkworth
Jan	2.0	2.2	2.0	0.9	1.5	0.7	2.5	1.5	1.9	1.2	4.5
Feb	2.7	2.4	1.4	1.8	1.3	0.9	1.7	2.6	4.2	0.7	10.1
Mar	5.2	2.5	9.3c	1.2	1.5	1.2	0.4c	3.6	6.2	1.1	10.1
Apr	1.2	1.2	0.6	0.6	0.5	0.2	0.6	1.9	2.8	0.4	7.2
May	0.9	1.7	0.7	1.4	1.8	1.1	1.0	2.8	5.8	0.9	10.9
Jun	0.8	1.0	0.9	2.0	2.6	1.6	1.7	2.8	6.1	1.9	14.9
Jul	3.8c	1.0	0.6	1.6	2.3	1.8	1.3	2.9	5.8	1.3	11.3
Aug	5.2c	1.8	1.9	1.8	1.7	2.4	1.9	4.7c	5.4	1.3	10.7
Sep	2.2	1.8	1.7	1.3	3.2c	1.3	1.3	2.6	6.1	1.2	9.8
Oct	1.7	2.3	1.2	1.7	1.0	1.6	1.7	1.0	6.6c	0.9	9.1
Nov	2.9	2.2	1.4	1.2	5.9	0.7	3.5	2.9	3.8	0.3	9.6
Dec	2.3	1.6	2.1	4.0	2.9	1.5	36.6c	0.6	10.9c	0.8	7.5
Annual Average	2.2	1.8	1.3	1.6	2.1	1.3	1.7	2.3	4.8	1.0	9.6

Table 2-2: HVO monthly deposited dust monitoring data (g/m²/month) – 2023

c - Sample contaminated, not included in annual average calculation



Figure 2-1: Monthly deposited dust results for 2023

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Figure 2-2 presents a plan of the dust gauge monitoring locations in the area around HVO and the annual average deposited dust levels. The figure includes annual windrose plots of the meteorological data collected at the Cheshunt and HVO Corporate Automatic Weather Stations (AWS) during 2023. Winds predominantly originated along a northwest/west-northwest and southeast/south-southeast axis at Cheshunt, and a west/west-northwest and southeast/east-southeast axis at HVO Corp.



Figure 2-2: Annual deposited dust results for 2023

As set out in the Air Quality Criteria section, deposited dust criteria are applicable for HVO North as per DA 450-10-2003. It is important to note that, there are no criteria applicable to HVO South for deposited dust levels per PA 06_0261.

When the measured cumulative annual average deposited dust level is below the criterion of 4g/m²/month it is generally inferred that compliance is achieved. The majority of dust which deposits on surfaces will not travel significant distances, and thus deposited dust levels are most affected by any very near sources. Hence if the cumulative criterion is exceeded, the applicant would need to

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show compliance with the maximum (incremental) increase in the deposited dust level of 2g/m²/month due to their activities, (which means there is a closer "other source" affecting the cumulative total reading). When the deposited dust level exceeds the criteria, the operator would need to further evaluate their compliance.

Figure 2-2 indicates that the DL30 and Warkworth monitors recorded an annual average of $4.8g/m^2/month$ and $9.6g/m^2/month$, respectively, in 2023 which were above the total criterion of $4g/m^2/month$.

It is noted that over the past few years, neighbouring mining activities along one of the prominent wind axes have progressed significantly closer toward the DL30 and Warkworth monitors which may be impacting the deposited dust levels.

Figure 2-2 shows that most of the deposited dust monitors are located in close proximity to HVO South, on the opposite side of HVO South from HVO North. Given the significant separation distances between HVO North and these monitors, HVO North's contribution to these monitoring sites would be low and likely indiscernible from background concentrations and the influences of other mines. Therefore, HVO North could only reasonably have a tangible impact at its nearest monitors which include D112, D119 and DL2 and as such, it is considered that HVO North could not have had significantly contributed to the DL30 and Warkworth deposited dust levels.

Table 2-2 and **Figure 2-2** show that D112, D119 and DL2 recorded annual average deposited dust levels below both the incremental and cumulative criteria and because dust from a mine cannot "leap frog" a monitor and cause higher impacts beyond the monitor it can be inferred that HVO North was compliant per DA 450-10-2003 at these and all other locations beyond. Note that D112 and DL2 are not compliance monitoring locations, however DL2 is on a prevailing wind axis relative to the HVO North operations and is perhaps the best sited monitor to indicate the deposited dust levels due to the operation at that distance downwind.

2.4.1 Deposited Dust Investigation

A simple and conservative approach has been adopted in order to calculate HVO North's contribution to the levels recorded at the deposited dust gauges. If monitors were downwind of HVO North for less than 5% of the time during the monthly sample period, HVO North's contribution to the monitor was assumed to be zero for that sample. If the monitors were downwind of HVO North for at least 5% of the time, then HVO North's contribution was assumed to be the total recorded level minus the minimum recorded monthly value in the monitoring network. This estimation is likely to overestimate the contribution from HVO North as it assumes the total difference between the recorded value and the low background level is due to HVO North and does not account for the likely impact of other sources such as neighbouring mines or localised sources. For monitors outside HVO North's reasonable range of impact (as discussed above), HVO North's contribution (D112, D119 or DL2). Monthly contributions were not calculated for monitors where the relevant monthly sample was invalid.

Table 2-3 presents the annual average deposited levels recorded in 2023 and HVO North's estimated contribution to the annual average deposited dust levels. The analysis shows that the estimated incremental contributions from HVO North to all monitors, including the elevated annual level at the Warkworth would be below the incremental annual average criterion of 2g/m²/month.

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The analysis shows that HVO North's conservatively calculated contribution to the DL30 and Warkworth monitors in 2023 would have been a maximum of $0.4g/m^2/month$ or 9% of the $4.8g/m^2/month$, and $0.1g/m^2/month$ or 1% of the $9.6g/m^2/month$, respectively. This indicates that the deposited dust level at DL30 and Warkworth in 2023 would be over the applicable total criterion of $4g/m^2/month$ regardless of the contribution from HVO North.

Π	Vonth	D112	D118	D119	D122	DL14	DL2	DL21	DL22	DL30	Lane	Warkworth
					Percer	ntage of t	ime dowi	nwind of	HVO (nor	th) (%)		
Ja	anuary	5%	2%	5%	4%	5%	5%	5%	5%	4%	5%	1%
Fe	ebruary	9%	6%	7%	11%	19%	23%	17%	14%	10%	14%	4%
1	March	7%	4%	3%	17%	27%	32%	25%	19%	10%	22%	3%
	April	7%	2%	3%	16%	31%	37%	26%	21%	11%	22%	6%
	May	5%	3%	2%	27%	55%	64%	47%	36%	24%	40%	8%
	June	5%	1%	1%	28%	66%	76%	52%	33%	16%	41%	4%
	July	6%	2%	3%	25%	66%	73%	54%	30%	19%	40%	5%
A	August	9%	3%	4%	24%	46%	55%	39%	30%	18%	34%	7%
Sep	ptember	10%	3%	3%	24%	43%	48%	38%	32%	23%	34%	9%
0	october	8%	2%	3%	18%	35%	45%	31%	23%	13%	26%	5%
No	ovember	7%	3%	4%	10%	20%	24%	17%	11%	8%	13%	3%
De	ecember	9%	4%	6%	11%	22%	32%	18%	14%	8%	15%	3%
N	Vonth			H۷	O month	ly deposi	ted dust ı	monitorin	g data (g	/m²/mon	th)	
Ja	anuary	2.0	2.2	2.0	0.9	1.5	0.7	2.5	1.5	1.9	1.2	4.5
Fe	ebruary	2.7	2.4	1.4	1.8	1.3	0.9	1.7	2.6	4.2	0.7	10.1
1	March	5.2	2.5	9.3c	1.2	1.5	1.2	0.4c	3.6	6.2	1.1	10.1
	April	1.2	1.2	0.6	0.6	0.5	0.2	0.6	1.9	2.8	0.4	7.2
	May	0.9	1.7	0.7	1.4	1.8	1.1	1.0	2.8	5.8	0.9	10.9
	June	0.8	1.0	0.9	2.0	2.6	1.6	1.7	2.8	6.1	1.9	14.9
	July	3.8c	1.0	0.6	1.6	2.3	1.8	1.3	2.9	5.8	1.3	11.3
A	August	5.2c	1.8	1.9	1.8	1.7	2.4	1.9	4.7c	5.4	1.3	10.7
Sep	ptember	2.2	1.8	1.7	1.3	3.2c	1.3	1.3	2.6	6.1	1.2	9.8
0	october	1.7	2.3	1.2	1.7	1.0	1.6	1.7	1.0	6.6c	0.9	9.1
No	ovember	2.9	2.2	1.4	1.2	5.9	0.7	3.5	2.9	3.8	0.3	9.6
De	ecember	2.3	1.6	2.1	4.0	2.9	1.5	36.6c	0.6	10.9c	0.8	7.5
Annu	al average	2.2	1.8	1.3	1.6	2.1	1.3	1.7	2.3	4.8	1.0	9.6
Month	Estimated Background			HVO Nor	th's maxi	mum esti	mated co	ontributio	n to mon	itor (g/m	²/month)	
Jan	0.7	1.3	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
Feb	0.7	2.0	1.7	0.7	0.2*	0.2*	0.2	0.2*	0.2*	0.2*	0.2*	0.0
Mar	1.1	4.1	0.0	-	0.0*	0.0*	0.1	-	0.0*	0.0*	0.0*	0.0
Apr	0.2	1.0	0.0	0.0	0.0*	0.0*	0.0	0.0*	0.0*	0.0*	0.0*	0.0*
May	0.7	0.0	0.0	0.0	0.4*	0.4*	0.4	0.4*	0.4*	0.4*	0.4*	0.4*
Jun	0.8	0.0	0.0	0.0	0.8*	0.8*	0.8	0.8*	0.8*	0.8*	0.8*	0.0
Jul	0.6	-	0.0	0.0	1.2*	1.2*	1.2	1.2*	1.2*	1.2*	1.2*	0.0
Aug	1.3	-	0.0	0.0	1.1*	1.1*	1.1	1.1*	-	1.1*	1.1*	1.1*
Sep	1.2	1.0	0.0	0.0	0.1*	-	0.1	0.1*	0.1*	0.1*	0.1*	0.1*
Oct	0.9	0.8	0.0	0.0	0.7*	0.7*	0.7	0.7*	0.7*	-	0.7*	0.0
Nov	0.3	2.6	0.0	0.0	0.4*	0.4*	0.4	0.4*	0.4*	0.4*	0.4*	0.0
Dec	0.6	1.7	0.0	1.5	0.9*	0.9*	0.9	-	0.9*	-	0.9*	0.0
Annual average	0.8	1.5	0.1	0.2	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.1

Table 2-3: HVO North's estimated contribution and annual average deposited dust levels 2023

*Contribution assumed to be equal to (or less than) that of intermediate DL2 monitor. Note that D112 and DL2 are not compliance monitors.

2.5 PM_{2.5} Data

Figure 2-3 presents the 24-hour average $PM_{2.5}$ HVAS results recorded during 2023 for Kilburnie South and Maison Dieu. The figures show that on occasion in 2023, 24-hour average $PM_{2.5}$ levels above the criteria were recorded. The results were assessed through investigation, as summarised in **Table C-1** of **Appendix C** and were found to have not been significantly contributed to by HVO.



Table 2-4 includes the annual average HVAS $PM_{2.5}$ monitoring data for Maison Dieu and Kilburnie South in 2023. The monitoring data for the 2023 review period show that the HVO monitors recorded levels above $8\mu g/m^3$.

Table 2-4: HVAS PW _{2.5} annual average monitoring data – 2023				
Location	Measured HVAS PM _{2.5} (µg/m ³)			
Maison Dieu	11.1			
Kilburnie South	13.3			

Table 2-4: HVAS PMar ann	ual average	monitoring	data - 2023
Table 2-4. ITVAS FIVI2.5 and	uaraverage	monitoring	uala – 2023

Table 2-5 includes the UHAQMN PM_{2.5} annual average data for the 2023 period. The monitoring data for the 2023 review period show that the UHAQMN monitors recorded levels below 8µg/m³.

Table 2-5: UHAQMN PM _{2.5} levels – 2023				
Monitor	Measured PM _{2.5} level (µg/m³)			
Muswellbrook	7.5			
Singleton	6.7			
Camberwell	6.1			
Merriwa	4.7			

The annual average PM_{2.5} levels during the 2023 period are shown at their monitor locations in **Figure 2-4**. The figure also includes annual windrose plots of the meteorological data collected at the Cheshunt and HVO Corp Automatic Weather Stations (AWS) during 2023.

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Figure 2-4: HVAS PM_{2.5} results for 2023

The data in **Table 2-4** and **Table 2-5** show that the $PM_{2.5}$ HVAS results recorded at Maison Dieu and Kilburnie South were high in comparison to the results recorded by the DCCEEW monitoring stations. This is unusual considering both Kilburnie South and Maison Dieu monitors are situated away from any known significant sources of $PM_{2.5}$ (mines generate emissions in the coarser PM_{10} range), whereas the Muswellbrook, and to a lesser extent Singleton and Camberwell monitors, are known to be impacted by localised smoke from wood heaters. This is highlighted further in **Table 2-6** which shows the ratio of $PM_{2.5}$ / PM_{10} levels in the Upper Hunter since 2015. Both HVO monitors recorded higher $PM_{2.5}$ / PM_{10} ratios in 2023 than any other Upper Hunter monitor.

The PM_{2.5} / PM₁₀ ratios in 2023 for the Maison Dieu and Kilburnie South monitor are implausibly high for this locality, indicating a likely problem with the data. This is considered in more detail below.

Table 2-6: PM _{2.5} / PM ₁₀ ratios in Upper Hunter							
Veer	PM _{2.5} / PM ₁₀ ratio						
rear	Muswellbrook	Singleton	Camberwell	Merriwa	Maison Dieu	Kilburnie South	
2015	0.46	0.39	0.33	-	-	-	

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Veer			PM _{2.5} / P	M ₁₀ ratio		
rear	Muswellbrook	Singleton	Camberwell	Merriwa	Maison Dieu	Kilburnie South
2016	0.44	0.41	0.31	-	-	-
2017	0.43	0.39	0.27	-	-	-
2018	0.35	0.34	0.27	-	-	-
2019	0.35	0.36	0.26	-	-	-
2020	0.41	0.41	0.31	-	0.63	0.78
2021	0.41	0.37	0.30	0.38	0.48	0.54
2022	0.39	0.36	0.32	0.31	0.40	0.57
2023	0.35	0.37	0.30	0.34	0.43	0.62

- Not Applicable

Figure 2-5 shows how the $PM_{2.5}$ / PM_{10} ratios fluctuated over the year. Both locations at times recorded $PM_{2.5}$ levels which were higher than the recorded PM_{10} levels (i.e. $PM_{2.5}$ / PM_{10} ratio >1), which in reality is not possible given that $PM_{2.5}$ is a sub-component of PM_{10} . This may be explained at Maison Dieu by the different measurement technology (TEOM) used to measure PM_{10} , which can result in slight differences in results, however at Kilburnie South both co-located $PM_{2.5}$ and PM_{10} measurements are conducted using the same reference standard of HVAS monitors.

The $PM_{2.5}$ / PM_{10} ratios at Maison Dieu and Kilburnie South were 0.43 and 0.62 on average for the whole year in 2023. Typically, the normal $PM_{2.5}$ / PM_{10} ratio of background particulate data is approximately 0.36 (**TAS, 2019**). Particulate emissions from HVO have a ratio of approximately 0.13 and Hunter Valley coal mines on average have a ratio of 0.15 (**PEL, 2014**). During only the wintertime in Muswellbrook, when air quality is significantly impacted by the $PM_{2.5}$ content of the local woodheater smoke, and average $PM_{2.5}$ / PM_{10} ratio (for eight winters) is 0.68, but can be approximately 0.8 in some winters.



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The high $PM_{2.5}$ / PM_{10} ratios, combined with the unusually high $PM_{2.5}$ results, indicate that there may be an issue (i.e. an overestimation) with the $PM_{2.5}$ measurements.

2.5.1 BAM monitoring

HVO commissioned BAM instruments at Moses Crossing and Maison Dieu in March 2023 and have been collecting PM_{2.5} data from both HVAS and BAMs units. PM₁₀ data are also collected at these locations, with a HVAS at Moses Crossing and a Tapered Element Oscillating Microbalance (TEOM) at Maison Dieu. The use of these BAM instruments is pending DPHI approval of the AQGHG Management Plan and will be used to complement HVO's existing reactive dust system and PM₁₀ alarms, in order to notify operations of high dust events and potential exceedances. The **TAS (2023)** review presents a detailed analysis of the HVAS and BAM monitoring data.

Figure 2-6 presents the locations of the HVO $PM_{2.5}$ and PM_{10} monitoring instruments (including BAM, HVAS and TEOM monitors) and the HVO weather stations.



Figure 2-6: HVO PM_{2.5} and PM₁₀ monitoring network

Table 2-7 includes the annual average BAM $PM_{2.5}$ monitoring data for Maison Dieu and Moses Crossing in 2023. It is to be noted that the annual average levels for these BAM monitors have been calculated based on data available from March 2023 to December 2023 (10 months) and is not indicative of a full year of monitoring. Hence, the annual average levels presented below are not applicable to be compared to annual average $PM_{2.5}$ criterion. Regardless, the monitoring data for the 2023 review period show that the HVO monitors recorded levels below $8\mu g/m^3$.

Table 2-7: BAM PM _{2.5} annual average monitoring data – 2023				
Location Measured BAM PM _{2.5} (μg/m ³				
Maison Dieu	4.8			
Moses Crossing	4.9			

Figure 2-7 presents the $PM_{2.5}$ data collected by the BAM instruments since their establishment. The figure shows that the 24-hour average levels recorded by the instruments at Maison Dieu and Moses Crossing were relatively similar and were well below the relevant criterion of $25\mu g/m^3$ in the review period, except for the Moses Crossing monitor on 19 December 2023, however this day was determined to be an extraordinary event due to widespread bushfires.



Figure 2-7: 24-hour average PM_{2.5} BAM data

2.5.2 PM_{2.5} Investigation

The aim of this analysis is to determine the potential contribution of HVO South to the 2023 annual average PM_{2.5} levels recorded at the HVO HVAS monitors.

Given that the results recorded at the Maison Dieu and Kilburnie South HVAS monitors appear to be implausibly high, the BAM PM_{2.5} monitoring data at these locations have been used in order to estimate HVO South's increment to the recorded levels. The estimated percentage contribution at the

BAM monitors has been applied to the HVAS monitoring results for only the HVAS run days. This provides a more plausible contribution of HVO to the HVAS monitors during 2023.

The HVO South contributions to the BAM monitors were estimated on an hourly basis. The hourly contributions were estimated as the concentrations recorded at each monitor minus the estimated background level. The contribution for a given hour was considered to be zero where the monitor was not downwind of HVO South for that hour. The hourly contributions were then averaged for each 24-hour period to determine the 24-hour contributions from HVO South. The percentage contribution of the total level recorded at the BAM monitors was applied to the HVAS monitoring results from March 2023 onwards to determine the potential contribution from HVO South to the monitors.

Given that the BAM monitoring did not commence until March 2023, the HVAS monitoring results were used to determine the contribution from HVO South at the monitors. The contributions at the HVAS monitors were estimated to be the 24-hour concentrations recorded at each monitor minus an estimated background level on the corresponding day. The background level in this context is considered to be the level which excludes the contribution from HVO but may include the influence of other sources, including other mines, localised sources, or regional sources of background dust.

For days when the monitor was not downwind of HVO South (i.e. <5% downwind), the HVO South contribution to this monitor was considered to be zero. Where the monitor was downwind of HVO South for some part of the day, the background levels for that day were taken to be the average level recorded by the upwind monitor. If the other PM_{2.5} HVAS was not upwind (i.e. >5% downwind), the average of the levels recorded at Camberwell and Singleton were used as background.

Note that the 24-hour average contributions presented in this analysis are estimated using a simplistic and conservative method based on the daily contributions and would likely overestimate the HVO South actual 24-hour average contribution. Therefore, the data presented in this section should only be used for conservatively estimating levels on an annual average basis. A more detailed analysis was conducted for some days where levels exceeded the 24-hour average criterion. Days in which HVO South's contribution were already estimated (analyses for elevated 24-hour average readings) are presented in **Table C-1** of **Appendix C**.

Table 2-8 presents the annual average PM_{2.5} levels recorded in 2023 and HVO South's estimated contribution to the annual average PM_{2.5} levels. **Table C-2** of **Appendix C** shows the 24-hour average PM_{2.5} levels and the estimated PM_{2.5} contribution of HVO South at each of the HVO monitors for each monitoring day of 2023.

Location	Monitor Type	Compliance (level) (µg/m³)	Measured annual average PM _{2.5} level (μg/m³)	Estimated contribution to annual average PM _{2.5} level (μg/m³)
Maison Dieu	HVAS	8 (HVO South)	11.1	1.8
Kilburnie South	HVAS	8 (HVO South)	13.3	1.9

Table 2-8: HVO South's estimated	contribution and annual	average PM _{2.5} levels 2023

Table 2-11 indicates that maximum HVO contributions, would have been:

- 1.8µg/m³ or 16% of the 11.1µg/m³ from HVO South at the Maison Dieu HVAS in 2023; and,
- + 1.9µg/m³ or 15% of the 13.3µg/m³ from HVO South at the Kilburnie South HVAS in 2023.

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2.6 PM₁₀ Data

Figure 2-8, **Figure 2-9** and **Figure 2-10** present the 24-hour average HVO PM₁₀ HVAS and PM₁₀ TEOM compliance and non-compliance monitor results recorded during 2023 respectively. The HVAS and TEOM PM₁₀ data show reasonably similar trends through 2023. The figures show that on occasion in 2023, 24-hour average PM₁₀ levels above the criteria were recorded. The elevated results at compliance monitors were assessed through specific investigations conducted throughout the year, as summarised in **Table B-1** of **Appendix B**.



Figure 2-8: 24-hour average PM₁₀ HVAS results for 2023



Figure 2-9: 24-hour average PM₁₀ TEOM results for 2023 – compliance monitors



Figure 2-10: 24-hour average PM_{10} TEOM results for 2023 – non-compliance monitors

Table 2-9 includes a summary of all the annual average HVAS and TEOM PM₁₀ monitoring data for the general HVO area in 2023. With regard to the HVAS PM₁₀ and TEOM PM₁₀ annual average data, obviously erroneous data, data with error codes and monitors which contain less than 75% data have not been included in **Table 2-9**.

Note for this annual review, TEOM data time was assessed per Australian Eastern Standard Time (AEST) as used by DCCEEW, however some minor differences arise with the operational data which

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uses Australian Eastern Daylight Time (AEDT). Some minor differences also arise as HVO collects data in real-time from DCCEEW monitors using a separate HVO logger which may result in minor additional time shift effect.

The table shows that the TEOM and HVAS monitors recorded annual average PM₁₀ levels below the relevant criteria in 2023, except the Gliding Club HVAS and Warkworth TEOM monitors.

Location	Measured HVAS PM ₁₀ (μg/m ³)	Measured TEOM PM ₁₀ (µg/m ³)
Wandewoi	-	19.1
Golden Highway	-	29.1
Howick	-	28.2
Knodlers Lane	-	24.0
Warkworth	-	32.5
Jerrys Plains	-	19.7
Maison Dieu	-	20.9
Cheshunt East	29.5	-
Gliding Club	31.7	-
Long Point	20.9	-
Kilburnie South	20.3	-

Table 2-9: HVAS and TEOM PM_{10} annual average monitoring data – 2023

Table 2-10 summarises the Upper Hunter Air Quality Monitoring Network (UHAQMN) PM_{10} annual average data for the 2023 period. The monitoring data for the 2023 review period show that the levels recorded by the UHAQMN network were similar to those recorded by the monitors surrounding HVO, with all the monitors recording levels below $25\mu g/m^3$.

Table 2-10: UHAQMI	N PM ₁₀ levels – 2023
Monitor	Measured PM ₁₀ level (μg/m ³)
Muswellbrook	21.9
Singleton	19.1
Maison Dieu	20.9
Camberwell	20.9
Singleton NW	21.9
Mount Thorley	24.1
Bulga	17.3
Muswellbrook NW	20.0
Wybong	16.2
Aberdeen	15.5
Singleton South	19.4
Jerrys Plains	19.7
Warkworth	32.5
Merriwa	14.2

Annual average PM₁₀ levels during the 2023 period are shown in **Figure 2-11**. The figure includes annual windrose plots of the meteorological data collected at the Cheshunt and HVO Corp Automatic

Weather Stations (AWS) during 2023.

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Figure 2-11: Annual average HVAS and TEOM PM₁₀ results for 2023

2.6.1 PM₁₀ Investigation

The aim of this analysis is to determine the potential contribution of HVO North and HVO South to the 2023 annual average PM₁₀ levels recorded at the HVO TEOM and HVAS monitors.

The HVO North and HVO South contributions to the TEOM monitors were estimated on an hourly basis. The hourly contributions were estimated as the concentrations recorded at each monitor minus an estimated background level (average of upwind monitors) for the corresponding hour. The contribution for a given hour was considered to be zero where the monitor was not downwind of HVO (North/ South) for that hour. Where all monitors were downwind of HVO North/South (based on the representative Cheshunt or HVO Corp weather station), the minimum value recorded was selected as the background for that hour. The hourly contributions were then averaged for each 24-hour period to determine the 24-hour contributions from HVO North and HVO South.

The contributions at the HVAS monitors were estimated to be the 24-hour concentrations recorded at each monitor minus an estimated background level on the corresponding day.

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The background level in this context is considered to be the level which excludes the contribution from HVO but may include the influence of other sources, including other mines, localised sources, or regional sources of background dust.

For days when the monitor was not downwind of HVO North/ South (i.e. <5% downwind), the HVO North/ South contribution to this monitor was considered to be zero. Where the monitor was downwind of HVO North/ South for some part of the day, the background levels for that day were taken to be the average level recorded by the monitors in the local network which were downwind for less than 15% of the time. If the monitors were downwind of HVO for greater than 15% of the time, than the minimum measured levels across the monitors was taken as the background level.

Note that the 24-hour average contributions presented in this analysis are estimated using a simple, conservative method based on the daily contributions and would likely overestimate the HVO North/ South actual 24-hour average contribution. Where the downwind angle of the monitor from HVO North and South overlap, the estimated contributions for each HVO North and HVO South would include the influence of the other. Furthermore, the approach does not factor in dispersion of pollutants with distance, thus a more distant mine can make the same contribution as a closer mine for the same wind angle. This leads to calculating much higher contributions than may possibly be the actual case. Therefore, the data presented in this section should only be used for conservatively estimating levels on an annual average basis. A more detailed analysis was conducted for some days where levels exceed the 24-hour average criterion.

Table 2-11 presents the annual average PM₁₀ levels recorded in 2023 and HVO's estimated contribution to the annual average PM₁₀ levels, for each analysis. **Appendix B** shows the 24-hour average PM₁₀ levels and the estimated PM₁₀ contribution of HVO North and HVO South where relevant at each of the HVO monitors for each monitoring day of 2023. Days in which HVO's contribution were already estimated (analyses for elevated 24-hour average readings) are presented in **Table B-1** of **Appendix B** and were used where possible. It is noted that the 24-hour TEOM values presented in **Table B-1** are based on the raw AEST readings.

Location	Monitor Type	HVO Compliance (level)	Measured annual average PM ₁₀	Estimated contribution to annual average PM ₁₀ level (µg/m³)				
		(₩6/)	level (µg/m³)	HVO North	HVO South			
Wandewoi	TEOM	North (30) & South (25)	19.1	0.3	1.8			
Golden Highway	TEOM	-	29.1	-	-			
Howick	TEOM	-	28.2	-	-			
Knodlers Lane	TEOM	South (25)	24.0	-	3.7			
Warkworth	TEOM	South (25)	32.5	-	3.4			
Jerrys Plains	TEOM	North (30) & South (25)	19.7	0.7	2.0			
Maison Dieu	TEOM	South (25)	20.9	-	0.8			
Cheshunt East	HVAS	North (30)	29.5	12.0	-			
Gliding Club	HVAS	South (25)	31.7	-	12.8			
Long Point	HVAS	South (25)	20.9	-	3.4			
Kilburnie South	HVAS	North (30) & South (25)	20.3	1.6	3.0			

Table 2-11: HVO's maximum estimated contribution and annual average PM₁₀ levels 2023



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2.7 TSP Data

Table 2-12 and **Figure 2-13** summarise the annual average and 24-hour average TSP HVAS monitoring data respectively for the HVO area in 2023. The table shows that the TSP HVAS monitors recorded annual average levels below the criterion of 90µg/m³ in 2023, except the Warkworth monitor which recorded an annual average TSP level of 130.8µg/m³.

Location	Measured HVAS TSP level (µg/m ³)
Cheshunt East	65.4
Warkworth	130.8
Wandewoi	67.1
Maison Dieu	59.2
Long Point	58.0
Knodlers Lane	89.5
Kilburnie South	68.9



Figure 2-12: 24-nour average TSP HVAS results for 2023

The annual average TSP levels during the 2023 period are shown in **Figure 2-13**. The figure includes annual windrose plots of the meteorological data collected at the Cheshunt and HVO Corp Automatic Weather Stations (AWS) during 2023.



2.7.1 TSP Investigation

The aim of this analysis is to determine the potential contribution of HVO North and HVO South to the 2023 annual average TSP levels recorded at the HVO HVAS monitors.

The contributions at the TSP HVAS monitors were estimated to be the 24-hour concentrations recorded at each monitor minus an estimated background level on the corresponding day. The background level in this context is considered to be the level which excludes the contribution from HVO but may include the influence of other sources, including other mines, localised sources, or regional sources of background dust.

For days when the monitor was not downwind of HVO North/ South (i.e. <5% downwind), the HVO North/ South contribution to this monitor was considered to be zero. Where the monitor was downwind of HVO North/ South for some part of the day, the background levels for that day were taken to be the average level recorded by the monitors in the local network which were downwind for

less than 15% of the time. If the monitors were downwind of HVO for greater than 15% of the time, than the minimum measured levels across the monitors was taken as the background level.

For the Warkworth monitor, which is often downwind of HVO South and a neighbouring mine concurrently, the daily contribution is considered to include both mines. In order to determine the contribution from HVO South alone, the combined mining increment was scaled by the proportion of time the monitor was downwind of HVO South relative to the total time the monitor was downwind of both mines during each 24-hour average period.

Note that the 24-hour average contributions presented in this analysis are estimated using a simplistic and conservative method based on the daily contributions and would likely overestimate the HVO North/ South actual 24-hour average contribution. Where the downwind angle of the monitor from HVO North and South overlap, the estimated contributions for each HVO North and HVO South would include the influence of the other. Furthermore, the approach does not factor in dispersion of pollutants with distance, thus a more distant mine can make the same contribution as a closer mine for the same wind angle. This leads to calculating much higher contributions than may possibly be the actual case. Therefore, the data presented should only be used for estimating levels on an annual average basis.

Table 2-13 presents the annual average TSP levels recorded in 2023 and HVO's estimated contribution to the annual average TSP levels, for each analysis. **Appendix A** shows the 24-hour average TSP levels and the estimated TSP contribution of HVO North and HVO South where relevant at each of the HVO monitors for each monitoring day of 2023.

Location	HVO Compliance (level) (ug/m ³)	Measured annual average TSP level	Estimated contribution to annual average TSP level (µg/m³)					
	(1-6/ /	(μg/m³)	HVO North	HVO South				
Cheshunt East	North (90)	65.4	21.6	-				
Warkworth	South (90)	130.8	-	51.9				
Wandewoi	-	67.1	-	-				
Maison Dieu	South (90)	59.2	-	11.6				
Long Point	South (90)	58.0	-	12.3				
Knodlers Lane	South (90)	89.5	-	32.8				
Kilburnie South	North (90) & South (90)	68.9	10.3	17.3				

Table 2-13: HVO's estimated contribution and annual average TSP levels 2023

3 CONCLUSIONS

This investigation has reviewed the annual average deposited dust, TSP, PM_{10} , and $PM_{2.5}$ levels recorded at HVO during the 2023 calendar year.

An annual average deposited dust level above the cumulative criterion of 4g/m²/month was recorded at the DL30 and Warkworth monitor, however the analysis indicates that HVO North's contribution to these levels was well below the 2g/m²/month incremental criterion and that the total level would have been over 4g/m²/month regardless of any contribution from HVO North.

The annual average TSP, PM_{10} and $PM_{2.5}$ levels were above the relevant criteria at some compliance monitoring locations during 2023. The following monitors above the relevant criteria during 2023 include:

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- Annual average TSP Warkworth HVAS monitor;
- + Annual average PM₁₀ Warkworth TEOM and Gliding Club HVAS monitor; and,
- + Annual average PM_{2.5} Maison Dieu HVAS and Kilburnie South HVAS monitor.

An analysis was undertaken for the potential contribution from HVO North and South on the monitors and indicates that HVO did not contribute more than the relevant criteria to the annual average TSP, PM_{10} and $PM_{2.5}$ levels at the monitors during 2023.

4 REFERENCES

PEL (2014)

"Upper Hunter Air Quality Particle Model", Pacific Environment Limited, October 2014.

TAS (2019)

"Investigation into PM2.5/PM10 ratios for Hunter Valley Operations", Todoroski Air Sciences, March 2019.

TAS (2023)

"Review of PM_{2.5} Real Time Response Triggers", Todoroski Air Sciences, December 2023.



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Appendix A

24-hour Average Levels and Estimated Contributions - TSP



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		Pe	rcentage o	of time dov	vnwind (%)					HVO North's estimated max. contribution to TSP level (μg/m³)						
Date	Cheshunt East	Warkworth	Wandewoi	Maison Dieu	Long Point	Knodlers Lane	Kilburnie South	Estimated Background	Cheshunt East	Warkworth	Wandewoi	Maison Dieu	Long Point	Knodlers Lane	Kilburnie South	Cheshunt East	Kilburnie South
5/01/2023	0%	0%	0%	0%	0%	0%	0%	28.0	22.7	24.2	32.6	22.6	19.1	31.9	47.3	0.0	0.0
11/01/2023	0%	0%	4%	0%	0%	0%	0%	63.5	53.9		85.9	54.6	62.7	82.7	91.4	0.0	0.0
17/01/2023	0%	0%	13%	0%	0%	0%	0%	44.7	24.1	81.8	75.7	26.4	29.1	62.3	104.0	0.0	0.0
23/01/2023	0%	0%	8%	0%	0%	0%	4%	58.0	51.4	86.6	69.4	50.8	39.0	62.3	73.2	0.0	0.0
29/01/2023	33%	4%	21%	29%	13%	25%	13%	44.7	53.6	102.0	93.1		44.7	66.3	154.0	8.9	109.3
4/02/2023	100%	0%	0%	88%	29%	33%	0%	210.0	18.4	30.6	199.0	49.9	94.8	158.0	221.0	0.0	0.0
10/02/2023	33%	17%	8%	33%	13%	29%	4%	54.0	58.2	71.6	89.4	54.0	64.3	89.9	88.6	4.2	0.0
16/02/2023	13%	8%	17%	13%	8%	17%	13%	32.8	44.0	119.0	133.0	32.3	33.2	61.9	126.0	11.3	93.3
22/02/2023	0%	0%	0%	0%	0%	0%	0%	25.2	20.2	22.2	56.3		19.2	39.4	24.9	0.0	0.0
28/02/2023	0%	0%	0%	0%	0%	0%	0%	46.0	25.3	82.4	100.0	29.7	57.5	34.9	75.6	0.0	0.0
6/03/2023	92%	0%	4%	83%	67%	75%	0%	77.8	149.0	362.0	91.7	125.0	97.8	150.0	63.9	71.2	0.0
12/03/2023	29%	0%	0%	29%	4%	4%	0%	58.6	62.7	-	58.6	59.8	70.5	88.6	84.0	4.1	0.0
18/03/2023	29%	8%	38%	25%	13%	21%	17%	60.0	76.0	-	146.0	75.0	60.0	85.2	131.0	16.0	71.0
24/03/2023	21%	0%	4%	21%	21%	21%	0%	24.2	39.0	44.1	42.1	46.7	24.2	44.9	61.7	14.8	0.0
30/03/2023	92%	0%	0%	50%	29%	29%	0%	16.9	-	61.6	16.8	46.6	31.1	46.9	17.0	-	0.0
5/04/2023	13%	21%	8%	25%	8%	38%	4%	37.9	40.9	65.7	55.8	34.1	37.9	59.3	48.5	3.0	0.0
11/04/2023	79%	13%	0%	96%	58%	88%	0%	17.7	91.5	65.7	14.3	59.9	58.6	70.0	21.0	73.9	0.0
17/04/2023	8%	29%	0%	25%	4%	38%	0%	44.1	44.2	-	72.6	43.4	43.9	60.9	52.3	0.2	0.0
23/04/2023	0%	17%	33%	8%	0%	13%	4%	22.6	22.1	61.6	58.1	22.3	20.9	25.2	-	0.0	-
29/04/2023	71%	4%	0%	71%	29%	58%	0%	40.3	67.2	190.0	41.2	78.0	79.0	83.4	39.3	27.0	0.0
5/05/2023	54%	17%	4%	63%	33%	67%	4%	35.6	108.0	135.0	35.6	75.9	86.4	87.4	-	72.4	-
11/05/2023	8%	21%	8%	29%	0%	29%	4%	37.6	36.4	54.7	55.4	41.2	37.6	57.0	52.1	0.0	0.0
17/05/2023	4%	0%	0%	0%	0%	0%	0%	57.7	56.5	56.2	42.8	54.1	58.8	82.9	37.5	0.0	0.0
23/05/2023	58%	4%	4%	58%	58%	58%	0%	42.1	104.0	146.0	67.8	90.1	86.1	100.0	42.1	61.9	0.0
29/05/2023	100%	0%	0%	71%	29%	33%	0%	11.9	112.0	322.0	15.2	81.8	96.9	127.0	8.6	100.1	0.0
4/06/2023	0%	0%	0%	0%	0%	0%	0%	65.3	42.2	155.0	84.2	34.8	37.3	57.3	77.1	0.0	0.0
10/06/2023	88%	0%	0%	83%	54%	63%	0%	23.9	67.8	171.0	23.0	56.8	77.3	99.9	24.7	44.0	0.0
16/06/2023	75%	8%	4%	79%	71%	79%	0%	15.7	93.9	134.0	15.5	82.2	91.6	99.7	15.9	78.2	0.0
22/06/2023	50%	13%	33%	54%	25%	46%	4%	67.9	84.3	177.0	71.9	69.3	67.9	94.2	100.0	16.4	0.0

Table A-1: 24-hour average TSP HVAS levels, percent time downwind and estimated contributions – HVO North

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Date		Pe	rcentage o	of time dov	vnwind (%)					HVO North's estimated max. contribution to TSP level (μg/m³)						
28/06/2023	92%	0%	0%	88%	33%	33%	0%	9.6	61.1	139.0	7.4	68.7	47.5	76.7	11.7	51.6	0.0
4/07/2023	13%	4%	38%	13%	4%	4%	17%	50.9	41.0	85.6	26.1	50.5	22.9	44.7	27.3	0.0	0.0
10/07/2023	100%	0%	0%	88%	42%	42%	0%	9.2	121.0	201.0	8.9	86.8	65.7	91.9	9.5	111.8	0.0
16/07/2023	33%	0%	0%	25%	17%	25%	0%	52.3	89.3	193.0	36.5	86.5	90.4	109.0	52.3	37.0	0.0
22/07/2023	38%	17%	17%	42%	0%	46%	4%	56.2	54.7	115.0	44.7	61.5	65.9	75.4	46.5	0.0	0.0
28/07/2023	96%	0%	0%	71%	33%	46%	0%	30.6	138.0	249.0	30.5	81.4	88.8	119.0	30.6	107.5	0.0
3/08/2023	42%	17%	25%	54%	33%	58%	4%	59.7	75.4	93.0	49.2	74.8	50.2	75.0	59.7	15.7	0.0
9/08/2023	50%	25%	25%	54%	21%	54%	4%	70.6	87.9	160.0	63.2	71.3	72.4	78.9	70.6	17.3	0.0
15/08/2023	8%	0%	25%	8%	4%	4%	4%	38.4	29.9	45.8	31.3	32.6	23.0	52.1	38.8	0.0	0.0
21/08/2023	79%	4%	0%	63%	25%	54%	0%	12.4	67.7	152.0	12.2	45.0	53.8	76.8	12.6	55.3	0.0
27/08/2023	13%	8%	13%	25%	0%	29%	4%	30.0	34.9	88.0	78.2	32.3	25.0	54.8	58.9	5.0	0.0
2/09/2023	0%	21%	13%	8%	0%	13%	0%	55.8	48.7	244.0	86.6	40.8	53.5	65.2	76.6	0.0	0.0
8/09/2023	100%	0%	0%	58%	21%	25%	0%	15.3	30.1	102.0	17.0	29.7	32.7	57.0	13.6	14.8	0.0
14/09/2023	38%	4%	17%	42%	25%	42%	8%	46.1	73.2	137.0	113.0	62.1	46.1	102.0	108.0	27.1	61.9
20/09/2023	79%	17%	0%	83%	54%	75%	0%	103.7	179.0	352.0	109.0	142.0	152.0	218.0	98.3	75.4	0.0
26/09/2023	42%	4%	4%	42%	33%	42%	0%	101.0	123.0	157.0	88.8	88.4	117.0	163.0	101.0	22.0	0.0
2/10/2023	4%	0%	4%	4%	0%	0%	4%	131.9	91.9	229.0	134.0	90.2	82.5	166.0	126.0	0.0	0.0
8/10/2023	0%	4%	13%	4%	0%	4%	4%	75.0	79.6	84.3	69.7	44.2	45.7	121.0	79.9	0.0	0.0
14/10/2023	92%	4%	0%	67%	25%	33%	0%	38.1	109.0	219.0	29.8	90.1	132.0	138.0	46.3	71.0	0.0
20/10/2023	21%	8%	33%	29%	8%	33%	13%	60.5	82.5	144.0	98.7	75.4	60.5	126.0	103.0	22.0	42.5
26/10/2023	0%	0%	0%	0%	0%	0%	0%	53.2	35.4	73.3	33.8	37.6	31.8	87.7	49.2	0.0	0.0
1/11/2023	0%	0%	0%	0%	0%	0%	0%	66.8	42.6	121.0	82.7	48.3	41.4	80.7	86.8	0.0	0.0
7/11/2023	13%	4%	17%	13%	0%	17%	13%	25.5	27.0	108.0	97.0	24.7	26.2	33.6	75.6	1.6	50.2
13/11/2023	0%	0%	0%	0%	0%	0%	0%	73.0	50.7	118.0	97.7	48.6	54.0	93.9	117.0	0.0	0.0
19/11/2023	4%	8%	42%	4%	0%	4%	21%	45.8	43.3	182.0	126.0	37.8	39.3	62.8	126.0	0.0	80.2
25/11/2023	25%	8%	0%	25%	4%	13%	0%	35.6	22.7	68.0	36.6	19.2	19.7	90.2	35.6	0.0	0.0
1/12/2023	79%	0%	0%	54%	25%	25%	0%	42.5	56.1	172.0	47.9	43.6	37.4	69.2	42.5	13.6	0.0
7/12/2023	25%	4%	21%	25%	17%	21%	17%	73.7	97.5	145.0	139.0	91.4	73.7	151.0	134.0	23.8	60.3
13/12/2023	13%	17%	17%	13%	4%	17%	8%	73.0	87.0	153.0	112.0	98.9	73.0	208.0	112.0	14.0	39.0
19/12/2023	42%	8%	38%	46%	33%	42%	13%	116.0	120.0	196.0	138.0	142.0	123.0	192.0	116.0	4.0	0.0
25/12/2023	0%	0%	13%	0%	0%	0%	4%	26.3	23.6	32.0	25.4	18.6	26.8	30.7	28.1	0.0	0.0
31/12/2023	0%	0%	0%	0%	0%	0%	0%	63.9	33.0	76.7	78.5	31.4	36.6	142.0	89.6	0.0	0.0

- No data

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		Perc	entage o	of time d	lownwin	ıd (%)				24-ho	ur averag	e TSP lev	el (μg/m	3)		HVO South's estimated max. contribution to TSP level ($\mu g/m^3$)					
Date	Cheshunt East	Warkworth	Wandewoi	Maison Dieu	Long Point	Knodlers Lane	Kilburnie South	Estimated Background	Cheshunt East	Warkworth	Wandewoi	Maison Dieu	Long Point	Knodlers Lane	Kilburnie South	Warkworth	Maison Dieu	Long Point	Knodlers Lane	Kilburnie South	
5/01/2023	0%	0%	100%	0%	0%	0%	4%	28.0	22.7	24.2	32.6	22.6	19.1	31.9	47.3	0.0	0.0	0.0	0.0	0.0	
11/01/2023	0%	0%	96%	0%	0%	0%	42%	63.5	53.9	-	85.9	54.6	62.7	82.7	91.4	-	0.0	0.0	0.0	27.9	
17/01/2023	0%	0%	88%	0%	0%	0%	54%	44.7	24.1	81.8	75.7	26.4	29.1	62.3	104.0	0.0	0.0	0.0	0.0	59.3	
23/01/2023	0%	0%	75%	0%	0%	0%	29%	58.0	51.4	86.6	69.4	50.8	39.0	62.3	73.2	0.0	0.0	0.0	0.0	15.2	
29/01/2023	0%	25%	38%	8%	17%	25%	21%	44.7	53.6	102.0	93.1	-	44.7	66.3	154.0	43.0	-	0.0	21.6	109.3	
4/02/2023	0%	33%	0%	67%	71%	96%	0%	210.0	18.4	30.6	199.0	49.9	94.8	158.0	221.0	0.0	0.0	0.0	0.0	0.0	
10/02/2023	0%	50%	33%	8%	8%	21%	17%	54.0	58.2	71.6	89.4	54.0	64.3	89.9	88.6	15.1	0.0	10.3	35.9	34.6	
16/02/2023	4%	21%	67%	0%	0%	8%	33%	32.8	44.0	119.0	133.0	32.3	33.2	61.9	126.0	86.3	0.0	0.0	29.2	93.3	
22/02/2023	0%	0%	96%	0%	0%	0%	8%	25.2	20.2	22.2	56.3		19.2	39.4	24.9	0.0	-	0.0	0.0	0.0	
28/02/2023	0%	0%	100%	0%	0%	0%	29%	46.0	25.3	82.4	100.0	29.7	57.5	34.9	75.6	0.0	0.0	0.0	0.0	29.6	
6/03/2023	0%	75%	0%	17%	33%	83%	4%	77.8	149.0	362.0	91.7	125.0	97.8	150.0	63.9	232.5	47.2	20.0	72.2	0.0	
12/03/2023	0%	4%	67%	25%	25%	29%	33%	58.6	62.7	-	58.6	59.8	70.5	88.6	84.0	-	1.2	11.9	30.0	25.4	
18/03/2023	0%	29%	46%	8%	8%	21%	8%	60.0	76.0	-	146.0	75.0	60.0	85.2	131.0	-	15.0	0.0	25.2	71.0	
24/03/2023	13%	21%	63%	8%	13%	21%	38%	24.2	39.0	44.1	42.1	46.7	24.2	44.9	61.7	12.4	22.5	0.0	20.7	37.5	
30/03/2023	0%	29%	0%	67%	38%	100%	0%	16.9	-	61.6	16.8	46.6	31.1	46.9	17.0	13.6	29.7	14.2	30.0	0.0	
5/04/2023	4%	38%	67%	4%	0%	8%	33%	37.9	40.9	65.7	55.8	34.1	37.9	59.3	48.5	25.0	0.0	0.0	21.4	10.6	
11/04/2023	0%	88%	0%	8%	17%	67%	0%	17.7	91.5	65.7	14.3	59.9	58.6	70.0	21.0	43.9	42.3	41.0	52.4	0.0	
17/04/2023	4%	38%	63%	4%	0%	4%	33%	44.1	44.2	-	72.6	43.4	43.9	60.9	52.3	-	0.0	0.0	0.0	8.3	
23/04/2023	0%	21%	67%	0%	0%	0%	8%	22.6	22.1	61.6	58.1	22.3	20.9	25.2	-	39.0	0.0	0.0	0.0	-	
29/04/2023	0%	58%	8%	25%	29%	54%	4%	40.3	67.2	190.0	41.2	78.0	79.0	83.4	39.3	104.8	37.8	38.8	43.2	0.0	
5/05/2023	13%	67%	8%	4%	0%	38%	4%	35.6	108.0	135.0	35.6	75.9	86.4	87.4	-	88.4	0.0	0.0	51.8	-	
11/05/2023	13%	33%	58%	4%	0%	0%	17%	37.6	36.4	54.7	55.4	41.2	37.6	57.0	52.1	13.7	0.0	0.0	0.0	14.5	
17/05/2023	4%	0%	71%	8%	4%	4%	13%	57.7	56.5	56.2	42.8	54.1	58.8	82.9	37.5	0.0	0.0	0.0	0.0	0.0	
23/05/2023	4%	63%	29%	0%	0%	58%	8%	42.1	104.0	146.0	67.8	90.1	86.1	100.0	42.1	97.4	0.0	0.0	57.9	0.0	
29/05/2023	0%	33%	0%	58%	71%	96%	0%	11.9	112.0	322.0	15.2	81.8	96.9	127.0	8.6	112.8	69.9	85.0	115.1	0.0	
4/06/2023	0%	0%	100%	0%	0%	0%	42%	65.3	42.2	155.0	84.2	34.8	37.3	57.3	77.1	0.0	0.0	0.0	0.0	11.8	
10/06/2023	4%	63%	4%	25%	29%	79%	4%	23.9	67.8	171.0	23.0	56.8	77.3	99.9	24.7	105.1	33.0	53.5	76.1	0.0	
16/06/2023	8%	83%	0%	4%	8%	71%	0%	15.7	93.9	134.0	15.5	82.2	91.6	99.7	15.9	112.7	0.0	75.9	84.0	0.0	
22/06/2023	0%	58%	25%	13%	8%	38%	13%	67.9	84.3	177.0	71.9	69.3	67.9	94.2	100.0	89.8	1.4	0.0	26.3	32.1	
28/06/2023	4%	33%	0%	46%	75%	96%	0%	9.6	61.1	139.0	7.4	68.7	47.5	76.7	11.7	51.8	59.2	38.0	67.2	0.0	

Table A-2: 24-hour average TSP HVAS levels, percent time downwind and estimated contributions – HVO South

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Date		Perc	entage o	f time d	ownwin	ıd (%)				24-ho	ur averag	e TSP lev	el (μg/m	3)		HVO South's estimated max. contribution to TSP level (µg/m ³)				
4/07/2023	8%	8%	25%	4%	13%	13%	17%	50.9	41.0	85.6	26.1	50.5	22.9	44.7	27.3	23.1	0.0	0.0	0.0	0.0
10/07/2023	0%	42%	0%	58%	83%	100%	0%	9.2	121.0	201.0	8.9	86.8	65.7	91.9	9.5	79.9	77.6	56.5	82.7	0.0
16/07/2023	8%	25%	58%	13%	13%	29%	4%	52.3	89.3	193.0	36.5	86.5	90.4	109.0	52.3	93.8	34.2	38.1	56.7	0.0
22/07/2023	13%	54%	25%	4%	4%	4%	4%	56.2	54.7	115.0	44.7	61.5	65.9	75.4	46.5	54.6	0.0	0.0	0.0	0.0
28/07/2023	0%	46%	0%	50%	58%	88%	0%	30.6	138.0	249.0	30.5	81.4	88.8	119.0	30.6	104.5	50.9	58.3	88.5	0.0
3/08/2023	8%	58%	8%	0%	0%	33%	4%	59.7	75.4	93.0	49.2	74.8	50.2	75.0	59.7	31.1	0.0	0.0	15.3	0.0
9/08/2023	8%	63%	0%	17%	21%	38%	0%	70.6	87.9	160.0	63.2	71.3	72.4	78.9	70.6	67.1	0.7	1.8	8.3	0.0
15/08/2023	21%	4%	42%	4%	4%	8%	42%	38.4	29.9	45.8	31.3	32.6	23.0	52.1	38.8	0.0	0.0	0.0	13.7	0.4
21/08/2023	8%	54%	0%	33%	38%	58%	0%	12.4	67.7	152.0	12.2	45.0	53.8	76.8	12.6	78.9	32.6	41.4	64.4	0.0
27/08/2023	0%	29%	67%	0%	0%	0%	21%	30.0	34.9	88.0	78.2	32.3	25.0	54.8	58.9	58.1	0.0	0.0	0.0	29.0
2/09/2023	8%	21%	71%	8%	0%	0%	38%	55.8	48.7	244.0	86.6	40.8	53.5	65.2	76.6	134.4	0.0	0.0	0.0	20.8
8/09/2023	0%	25%	0%	75%	79%	96%	0%	15.3	30.1	102.0	17.0	29.7	32.7	57.0	13.6	21.7	14.4	17.4	41.7	0.0
14/09/2023	0%	42%	46%	0%	0%	25%	25%	46.1	73.2	137.0	113.0	62.1	46.1	102.0	108.0	90.9	0.0	0.0	55.9	61.9
20/09/2023	0%	79%	0%	17%	25%	75%	0%	103.7	179.0	352.0	109.0	142.0	152.0	218.0	98.3	205.2	38.4	48.4	114.4	0.0
26/09/2023	4%	46%	38%	8%	0%	38%	8%	101.0	123.0	157.0	88.8	88.4	117.0	163.0	101.0	44.0	0.0	0.0	62.0	0.0
2/10/2023	4%	0%	88%	4%	4%	4%	33%	131.9	91.9	229.0	134.0	90.2	82.5	166.0	126.0	0.0	0.0	0.0	0.0	0.0
8/10/2023	0%	4%	88%	0%	0%	0%	38%	75.0	79.6	84.3	69.7	44.2	45.7	121.0	79.9	0.0	0.0	0.0	0.0	4.9
14/10/2023	0%	33%	0%	67%	67%	92%	0%	38.1	109.0	219.0	29.8	90.1	132.0	138.0	46.3	60.3	52.1	94.0	100.0	0.0
20/10/2023	0%	79%	29%	0%	0%	8%	4%	60.5	82.5	144.0	98.7	75.4	60.5	126.0	103.0	83.5	0.0	0.0	65.5	0.0
26/10/2023	0%	0%	100%	0%	0%	0%	21%	53.2	35.4	73.3	33.8	37.6	31.8	87.7	49.2	0.0	0.0	0.0	0.0	0.0
1/11/2023	0%	0%	100%	0%	0%	0%	63%	66.8	42.6	121.0	82.7	48.3	41.4	80.7	86.8	0.0	0.0	0.0	0.0	20.0
7/11/2023	4%	21%	71%	0%	0%	0%	21%	25.5	27.0	108.0	97.0	24.7	26.2	33.6	75.6	68.8	0.0	0.0	0.0	50.2
13/11/2023	0%	0%	100%	0%	0%	0%	79%	73.0	50.7	118.0	97.7	48.6	54.0	93.9	117.0	0.0	0.0	0.0	0.0	44.0
19/11/2023	0%	17%	54%	4%	4%	4%	25%	45.8	43.3	182.0	126.0	37.8	39.3	62.8	126.0	109.0	0.0	0.0	0.0	80.2
25/11/2023	0%	21%	58%	13%	13%	17%	13%	35.6	22.7	68.0	36.6	19.2	19.7	90.2	35.6	20.3	0.0	0.0	54.6	0.0
1/12/2023	0%	25%	17%	50%	67%	79%	0%	42.5	56.1	172.0	47.9	43.6	37.4	69.2	42.5	43.2	1.1	0.0	26.7	0.0
7/12/2023	0%	29%	58%	4%	8%	21%	33%	73.7	97.5	145.0	139.0	91.4	73.7	151.0	134.0	62.4	0.0	0.0	77.3	60.3
13/12/2023	4%	29%	46%	4%	4%	8%	29%	73.0	87.0	153.0	112.0	98.9	73.0	208.0	112.0	70.0	0.0	0.0	135.0	39.0
19/12/2023	4%	50%	4%	8%	17%	42%	17%	116.0	120.0	196.0	138.0	142.0	123.0	192.0	116.0	68.6	26.0	7.0	76.0	0.0
25/12/2023	4%	0%	88%	0%	0%	0%	25%	26.3	23.6	32.0	25.4	18.6	26.8	30.7	28.1	0.0	0.0	0.0	0.0	1.8
31/12/2023	0%	0%	100%	0%	0%	0%	48%	63.9	33.0	76.7	78.5	31.4	36.6	142.0	89.6	0.0	0.0	0.0	0.0	25.7

- No data

22121520I_Annual_review_HVO_2023_240327.docx

Appendix B

24-hour Average Levels and Estimated Contributions - PM₁₀



22121520I_Annual_review_HVO_2023_240327.docx
Date	Site	Measured 24-hour average PM10 level (μg/m³)	HVO 24-hour average PM10 Incremental Criteria (μg/m³)	Estimated HVO Incremental contribution to PM_{10} level ($\mu g/m^3$)
24/01/2023	Warkworth TEOM	54.6	50	0.0
27/01/2023	Warkworth TEOM	50.3	50	0.0
3/02/2023	Knodlers Lane TEOM	63.5	50	45.6
4/02/2023	Kilburnie South HVAS	56.6	50	0.0
6/02/2023	Warkworth TEOM	55.5	50	0.0
	Cheshunt East HVAS	61.1	50	20.3
6/03/2023	Warkworth TEOM	54.1	50	25.6
	Knodlers Lane TEOM	58.7	50	32.6
7/02/2022	Warkworth TEOM	63.1	50	12.5
7/03/2023	Knodlers Lane TEOM	65.1	50	44.8
	Warkworth TEOM	56.5	50	19.1
8/03/2023	Knodlers Lane TEOM	67.4	50	36.8
	Knodlers Lane TEOM	67.4	50	41.0
20/03/2023	Warkworth TEOM	60.7	50	0.0
25/05/2022	Knodlers Lane TEOM	59.4	50	0.0
23/03/2023	Warkworth TEOM	54.8	50	30.0
31/05/2023	Warkworth TEOM	50.8	50	6.3
22/06/2023	Gliding Club HVAS	50.5	50	13.6
26/06/2023	Warkworth TEOM	50.7	50	0.0
29/07/2023	Warkworth TEOM	55.7	50	11.8
9/08/2023	Gliding Club HVAS	53.2	50	36.1
7/09/2023	Warkworth TEOM	53.5	50	29.5
14/09/2023	Gliding Club HVAS	54.2	50	31.2
16/09/2023	Warkworth TEOM	59.2	50	6.1
17/00/2022	Knodlers Lane TEOM	53.0	50	27.4
17/05/2025	Warkworth TEOM	51.9	50	0.0
18/00/2022	Knodlers Lane TEOM	52.5	50	7.9
18/09/2023	Warkworth TEOM	50.6	50	0.0
19/09/2022	Knodlers Lane TEOM	53.9	50	14.9
13/03/2023	Warkworth TEOM	96.6	50	25.4
20/09/2022	Knodlers Lane TEOM	73.9	50	36.2
20/03/2023	Maison Dieu	54.2	50	11.1

Table B-1: Detailed analyses for elevated 24-hour average PM₁₀ readings



Date	Site	Measured 24-hour average PM10 level (μg/m³)	HVO 24-hour average PM10 Incremental Criteria (μg/m³)	Estimated HVO Incremental contribution to PM_{10} level (µg/m ³)
	Warkworth TEOM	93.5	50	10.2
	Gliding Club HVAS	124.0	50	87.5
	Cheshunt East HVAS	86.4	50	44.9
	Long Point HVAS	73.7	50	33.7
21/09/2023	Knodlers Lane TEOM	52.6	50	8.0
	Knodlers Lane TEOM	50.7	50	7.9
26/09/2023	Cheshunt East HVAS	50.3	50	15.5
	Gliding Club HVAS	65.8	50	15.5
1/10/2022	Warkworth TEOM	74.7	50	10.9
1/10/2023	Knodlers Lane TEOM	64.6	50	20.4
	Jerrys Plains TEOM	63.6	50	9.0
	Wandewoi TEOM	52.0	50	0.0
2/10/2023	Warkworth TEOM	63.5	50	0.0
	Gliding Club HVAS	81.0	50	29.9
	Kilburnie South HVAS	51.6	50	6.5
3/10/2023	Warkworth TEOM	63.3	50	0.0
4/10/2023	Warkworth TEOM	55.8	50	10.4
15/10/2023	Knodlers Lane TEOM	50.1	50	21.9
16/10/2022	Knodlers Lane TEOM	54.4	50	13.1
10/10/2023	Warkworth TEOM	54.8	50	0.0
21/10/2022	Jerrys Plains TEOM	50.7	50	0.0
21/10/2023	Warkworth TEOM	55.1	50	0.0
22/10/2022	Knodlers Lane TEOM	50.3	50	25.7
22/10/2023	Warkworth TEOM	69.7	50	0.0
23/10/2023	Warkworth TEOM	55.1	50	21.4
24/10/2023	Warkworth TEOM	52.1	50	0.0
	Knodlers Lane TEOM	81.9	50	27.5
25/10/2023	Maison Dieu TEOM	57.0	50	0.6
	Warkworth TEOM	64.9	50	0.0
30/10/2023	Warkworth TEOM	54.9	50	10.3
31/10/2023	Warkworth TEOM	73.8	50	0.0
12/11/2022	Knodlers Lane TEOM	59.5	50	46.9
12/11/2025	Warkworth TEOM	57.8	50	1.2



Date	Site	Measured 24-hour average PM10 level (μg/m³)	HVO 24-hour average PM10 Incremental Criteria (μg/m³)	Estimated HVO Incremental contribution to PM_{10} level (µg/m ³)
14/11/2023	Warkworth TEOM	52.0	50	8.4
19/11/2023	Warkworth TEOM	55.1	50	0.0
6/12/2022	Knoddlers Lane TEOM	51.2	50	8.9
6/12/2023	Warkworth TEOM	52.8	50	0.0
9/12/2023	Warkworth TEOM	51.3	50	42.9
10/12/2023	Warkworth TEOM	57.4	50	0.0
11/12/2022	Knoddlers Lane TEOM	50.8	50	0.0
11/12/2025	Warkworth TEOM	55.5	50	0.0
14/12/2022	Knoddlers Lane TEOM	51	50	49.2
14/12/2025	Warkworth TEOM	53.5	50	0.0
	Knoddlers Lane TEOM	57.4	50	0.0
15/12/2023	Wandewoi TEOM	54.4	50	0.0
	Warkworth TEOM	50.2	50	0.0
16/12/2022	Knoddlers Lane TEOM	56.6	50	16.6
16/12/2023	Warkworth TEOM	58.4	50	0.0
17/12/2022	Knoddlers Lane TEOM	61.9	50	0.0
17/12/2023	Warkworth TEOM	54.9	50	0.0
18/12/2022	Knoddlers Lane TEOM	52.6	50	0.0
18/12/2023	Warkworth TEOM	57.7	50	0.0
	Knoddlers Lane TEOM	56.7	50	4.6
	Maison Dieu TEOM	54.5	50	0.0
	Wandewoi TEOM	51.4	50	0.0
10/12/2022	Warkworth TEOM	60.1	50	0.0
13/12/2025	Cheshunt East HVAS	63.8	50	14.6
	Gliding Club HVAS	83.9	50	27.5
	Kilburnie South HVAS	56.4	50	22.3
	Long Point HVAS	63.0	50	6.6

Table B-2: 24-hour average PM₁₀ TEOM levels, percent time downwind and estimated contributions – HVO North

D	Date	24-hour average level (μg/m³)	Percentage of time downwind (%)	HVO North's estimated max. contribution to level (μg/m³)

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	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
1/01/2023	13.8	26.2	24.7	15.1	12.1	-	23.2	0%	100%	4%	0%	0%	0%	0%	0.8	-
2/01/2023	15.3	29.2	30.5	14.5	14.6	-	25.4	0%	92%	17%	0%	0%	4%	0%	3.4	-
3/01/2023	30.1	44.1	40.9	26.3	26.4	-	39.5	8%	67%	17%	21%	21%	8%	4%	0.1	-
4/01/2023	23.5	39.3	31.5	18.6	18.8	23.3	30.4	0%	92%	0%	4%	4%	8%	0%	0.0	0.0
5/01/2023	20.2	15.5	10.2	10.2	11.9	10.0	23.9	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
6/01/2023	18.6	13.1	7.1	15.0	15.0	7.6	7.4	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
7/01/2023	24.0	14.5	9.7	14.3	14.4	11.5	16.5	0%	100%	17%	0%	0%	0%	0%	0.2	0.0
8/01/2023	24.1	26.0	18.9	16.4	17.4	18.3	23.5	0%	96%	8%	0%	0%	0%	0%	0.0	0.0
9/01/2023	35.7	41.3	36.3	26.0	27.2	26.9	26.0	8%	63%	17%	29%	29%	4%	4%	3.0	0.0
10/01/2023	26.8	31.8	29.5	15.5	13.7	24.0	25.9	0%	83%	38%	4%	4%	4%	4%	5.2	0.0
11/01/2023	25.7	34.2	30.2	20.8	19.9	25.3	30.1	0%	100%	4%	0%	0%	0%	0%	0.5	0.0
12/01/2023	25.1	39.1	38.3	22.6	18.2	32.7	36.2	0%	92%	17%	0%	0%	4%	0%	3.3	0.2
13/01/2023	22.3	33.4	34.1	18.1	17.1	22.3	27.7	0%	100%	4%	0%	0%	0%	0%	0.5	0.0
14/01/2023	11.9	22.7	23.7	12.8	10.8	19.2	21.7	0%	100%	8%	0%	0%	0%	0%	0.7	0.0
15/01/2023	25.0	29.5	28.4	22.1	20.7	28.2	32.7	17%	50%	29%	25%	25%	21%	8%	2.9	0.7
16/01/2023	17.7	36.5	28.5	18.2	14.1	21.0	23.3	0%	100%	4%	0%	0%	0%	0%	0.4	0.0
17/01/2023	12.8	27.1	28.7	13.5	11.1	17.6	23.9	0%	83%	29%	0%	0%	13%	0%	3.6	0.1
18/01/2023	38.1	38.1	35.6	30.3	29.0	29.6	29.3	21%	33%	21%	29%	25%	21%	8%	4.4	1.6
19/01/2023	11.0	12.6	8.8	9.4	11.7	9.5	12.5	0%	63%	0%	13%	25%	8%	0%	0.0	0.2
20/01/2023	16.3	21.1	14.5	12.3	13.3	13.6	22.2	0%	100%	4%	0%	0%	0%	0%	0.0	0.0
21/01/2023	19.3	25.1	19.4	13.4	14.0	18.9	25.4	0%	96%	8%	0%	0%	0%	0%	0.1	0.0
22/01/2023	14.9	14.7	10.8	10.2	10.6	11.4	22.2	0%	96%	13%	0%	0%	0%	0%	0.3	0.0
23/01/2023	21.0	23.2	16.5	14.8	16.9	18.3	25.6	0%	75%	21%	0%	0%	8%	0%	1.4	0.6
24/01/2023	26.7	31.9	20.2	18.3	18.7	26.0	54.6	0%	67%	46%	0%	0%	17%	0%	0.3	0.4
25/01/2023	26.7	36.3	27.8	22.0	23.9	28.3	33.5	4%	67%	0%	8%	4%	8%	4%	0.0	0.0
26/01/2023	36.4	29.7	24.2	23.3	22.3	20.3	31.5	8%	29%	13%	50%	54%	13%	4%	0.0	0.3
27/01/2023	26.3	38.3	32.9	29.6	25.7	30.4	50.3	0%	96%	13%	0%	0%	0%	0%	1.6	0.0
28/01/2023	31.6	31.5	28.9	21.5	19.2	31.2	38.2	13%	58%	17%	25%	21%	13%	8%	0.8	0.2
29/01/2023	29.4	32.5	24.3	18.1	19.5	19.5	23.9	13%	33%	17%	25%	29%	21%	4%	1.4	0.5
30/01/2023	15.0	15.2	11.1	13.0	-	12.0	18.8	13%	54%	21%	17%	17%	13%	0%	0.0	0.0
31/01/2023	17.3	-	11.8	15.2	12.6	14.7	18.7	0%	75%	17%	0%	0%	13%	0%	0.0	0.0
1/02/2023	30.3	19.6	16.9	18.6	19.3	22.4	23.0	25%	46%	17%	21%	8%	13%	21%	0.0	0.0
2/02/2023	27.1	17.2	14.7	40.0	-	15.6	38.4	4%	29%	0%	29%	38%	4%	0%	0.0	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution to	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
3/02/2023	35.1	23.4	17.4	59.4	-	13.3	39.8	4%	0%	0%	29%	54%	0%	0%	0.0	0.0
4/02/2023	37.6	19.5	11.6	38.8	16.7	8.4	35.1	8%	0%	0%	33%	92%	0%	0%	0.0	0.0
5/02/2023	31.9	43.7	24.6	35.1	32.2	24.8	42.8	17%	33%	4%	50%	46%	13%	8%	0.0	0.0
6/02/2023	25.2	46.3	-	24.4	23.4	27.8	55.5	0%	75%	8%	0%	4%	13%	0%	-	0.2
7/02/2023	-	30.7	31.3	22.8	17.5	23.9	36.3	0%	96%	21%	0%	0%	0%	0%	4.5	0.0
8/02/2023	-	29.8	25.7	21.0	16.2	21.6	35.0	0%	100%	17%	0%	0%	0%	0%	1.6	0.0
9/02/2023	24.5	20.8	13.6	12.8	13.0	13.5	19.5	0%	71%	13%	0%	0%	17%	0%	0.0	0.2
10/02/2023	40.3	25.0	17.3	17.5	16.7	16.2	21.8	21%	38%	13%	29%	33%	13%	17%	0.0	0.0
11/02/2023	59.0	30.9	13.7	28.0	23.2	19.9	31.5	21%	17%	0%	50%	54%	13%	21%	0.0	0.0
12/02/2023	60.1	39.7	27.7	38.0	36.7	25.5	37.3	13%	38%	21%	46%	46%	4%	4%	5.1	0.0
13/02/2023	33.8	37.9	33.3	28.1	26.0	28.0	36.6	0%	100%	17%	0%	0%	0%	0%	1.4	0.0
14/02/2023	27.3	28.2	19.5	17.8	-	16.9	31.4	0%	96%	13%	0%	0%	0%	0%	0.5	0.0
15/02/2023	27.5	38.7	-	13.8	-	21.9	35.6	0%	96%	25%	0%	0%	0%	0%	-	0.0
16/02/2023	45.5	46.0	29.0	16.1	-	32.8	32.5	8%	63%	21%	17%	13%	17%	8%	2.4	0.5
17/02/2023	43.4	40.2	38.8	19.5	19.6	31.2	49.2	21%	54%	21%	21%	21%	8%	8%	3.1	0.0
18/02/2023	57.3	32.2	26.7	29.8	35.9	37.7	36.1	8%	29%	13%	42%	58%	21%	4%	2.2	0.0
19/02/2023	-	33.2	24.7	24.1	24.7	21.7	35.6	0%	88%	0%	4%	4%	0%	0%	0.0	0.0
20/02/2023	-	38.0	25.9	21.9	21.1	26.2	43.4	13%	71%	13%	21%	17%	21%	8%	0.8	0.2
21/02/2023	43.2	36.9	30.0	22.4	19.9	25.6	38.5	0%	71%	8%	4%	4%	21%	0%	0.3	0.3
22/02/2023	12.9	8.3	6.2	8.7	7.7	5.4	9.1	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
23/02/2023	20.2	20.8	-	14.5	13.9	13.3	22.4	0%	100%	8%	0%	0%	0%	0%	-	0.0
24/02/2023	19.8	18.2	16.0	11.3	11.7	17.0	23.7	0%	96%	21%	0%	0%	4%	0%	1.2	1.6
25/02/2023	20.6	25.2	18.9	11.7	11.8	23.0	26.1	13%	67%	17%	13%	13%	29%	13%	0.1	1.8
26/02/2023	41.8	18.7	15.7	20.7	18.7	28.1	25.7	21%	13%	4%	38%	50%	17%	13%	0.0	0.8
27/02/2023	47.8	32.3	21.6	29.7	30.4	24.3	37.8	8%	42%	0%	42%	46%	4%	4%	0.0	0.0
28/02/2023	22.9	26.2	24.7	18.3	17.2	19.9	32.0	0%	96%	13%	0%	0%	0%	0%	0.3	0.0
1/03/2023	28.7	25.6	21.0	19.1	19.5	19.0	28.2	13%	38%	13%	25%	33%	8%	8%	1.9	0.0
2/03/2023	20.6	24.3	26.0	16.7	12.3	16.7	22.8	0%	100%	25%	0%	0%	0%	0%	1.8	0.0
3/03/2023	18.8	28.2	22.7	14.6	13.2	17.7	25.7	0%	100%	4%	0%	0%	0%	0%	0.4	0.0
4/03/2023	20.4	28.7	18.6	14.7	12.1	15.7	29.8	0%	100%	17%	0%	0%	0%	0%	0.9	0.0
5/03/2023	30.3	35.9	23.6	35.6	25.4	23.7	26.7	13%	38%	17%	29%	25%	8%	13%	1.2	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution te	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
6/03/2023	40.6	33.0	25.6	58.7	32.3	27.4	54.1	8%	0%	4%	83%	92%	0%	0%	0.0	0.0
7/03/2023	44.5	35.1	22.7	65.1	42.9	18.6	63.1	4%	0%	0%	42%	79%	0%	4%	0.0	0.0
8/03/2023	39.9	43.3	29.2	66.8	45.3	23.0	56.5	0%	0%	0%	33%	38%	0%	0%	0.0	0.0
9/03/2023	41.9	43.5	36.0	41.0	40.0	32.2	46.9	4%	25%	0%	54%	67%	4%	0%	0.0	0.0
10/03/2023	35.1	53.1	36.0	24.2	23.9	30.1	45.2	13%	83%	4%	13%	13%	17%	13%	0.0	0.0
11/03/2023	30.3	35.0	24.5	25.1	26.6	20.9	29.8	13%	17%	4%	38%	54%	8%	8%	0.0	0.0
12/03/2023	26.8	33.6	22.3	23.4	22.7	18.7	31.7	0%	75%	0%	4%	21%	0%	0%	0.0	0.0
13/03/2023	22.7	18.9	18.5	15.5	17.1	14.5	-	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
14/03/2023	19.2	21.7	15.1	13.6	15.0	12.9	-	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
15/03/2023	28.3	30.9	23.9	17.9	19.2	23.9	40.2	8%	46%	13%	21%	21%	25%	8%	0.5	0.8
16/03/2023	40.4	24.3	26.4	34.2	28.2	17.1	36.3	13%	0%	0%	63%	79%	4%	0%	0.0	0.0
17/03/2023	33.2	48.1	35.3	33.5	38.9	38.4	46.6	17%	54%	4%	46%	46%	0%	4%	0.6	0.0
18/03/2023	38.4	59.1	35.1	26.3	29.6	42.5	35.1	8%	46%	4%	25%	29%	42%	8%	0.3	4.0
19/03/2023	53.9	53.7	31.7	35.8	30.4	38.6	38.0	13%	21%	8%	46%	54%	21%	4%	0.0	1.9
20/03/2023	39.6	56.6	37.5	33.3	30.5	40.3	60.7	0%	96%	21%	0%	0%	0%	0%	1.2	0.0
21/03/2023	21.5	28.9	25.0	16.7	17.8	25.5	44.0	0%	100%	4%	0%	0%	0%	0%	0.2	0.0
22/03/2023	29.2	37.7	24.1	18.4	18.7	24.9	33.8	0%	96%	21%	0%	0%	4%	0%	2.4	0.2
23/03/2023	19.6	-	16.0	30.5	18.6	18.4	28.7	4%	17%	8%	46%	67%	4%	4%	0.3	0.1
24/03/2023	-	21.5	14.4	11.8	16.5	15.0	21.8	0%	71%	4%	13%	13%	4%	0%	0.0	0.0
25/03/2023	-	11.5	13.8	6.3	8.6	18.4	31.4	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
26/03/2023	-	16.7	19.2	8.9	10.8	27.1	39.0	0%	100%	4%	0%	0%	0%	0%	0.1	0.0
27/03/2023	-	16.6	9.8	8.6	11.0	14.1	13.1	8%	17%	8%	63%	63%	25%	8%	0.0	2.4
28/03/2023	17.2	17.7	12.3	12.1	16.2	14.4	-	8%	50%	4%	38%	42%	4%	4%	0.0	0.0
29/03/2023	14.0	8.5	9.5	11.1	13.1	10.1	15.4	8%	4%	0%	75%	96%	0%	4%	0.0	0.0
30/03/2023	10.4	4.2	8.0	13.1	14.5	7.0	12.2	0%	0%	0%	29%	46%	0%	0%	0.0	0.0
31/03/2023	43.2	12.8	9.2	15.5	15.5	7.5	18.3	4%	4%	0%	50%	71%	0%	0%	0.0	0.0
1/04/2023	26.1	24.3	10.8	16.7	17.1	12.0	24.7	13%	42%	4%	46%	46%	0%	8%	0.0	0.0
2/04/2023	28.3	-	13.0	14.9	13.3	13.4	27.1	0%	96%	4%	0%	0%	4%	0%	0.0	0.0
3/04/2023	15.5	23.5	17.6	11.2	10.6	21.2	45.1	0%	92%	29%	0%	0%	0%	0%	1.2	0.0
4/04/2023	23.7	21.4	14.8	10.5	9.7	18.1	30.3	4%	88%	4%	8%	8%	4%	0%	0.0	0.0
5/04/2023	30.5	29.1	12.6	15.4	14.9	19.9	20.9	29%	67%	17%	33%	25%	4%	21%	0.9	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution te	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
6/04/2023	28.1	34.3	14.7	31.3	11.0	22.0	26.4	21%	75%	33%	21%	8%	17%	25%	1.5	1.5
7/04/2023	22.8	19.4	9.9	13.8	10.6	14.6	21.1	8%	17%	13%	63%	75%	13%	4%	0.1	0.0
8/04/2023	21.3	15.9	10.6	21.3	17.0	11.8	48.4	0%	0%	0%	4%	50%	0%	0%	0.0	0.0
9/04/2023	16.4	12.8	9.3	19.4	19.7	9.1	38.6	0%	0%	0%	0%	75%	0%	0%	0.0	0.0
10/04/2023	16.6	10.1	8.4	16.7	11.4	7.6	24.3	0%	0%	0%	33%	67%	0%	0%	0.0	0.0
11/04/2023	24.2	22.1	10.7	16.2	17.8	8.9	20.2	29%	0%	0%	92%	96%	0%	13%	0.0	0.0
12/04/2023	34.8	17.8	11.1	24.5	19.6	12.1	24.6	0%	13%	4%	33%	58%	8%	0%	0.0	0.0
13/04/2023	20.7	11.3	8.1	13.7	12.6	8.5	11.9	4%	63%	4%	33%	38%	0%	0%	0.0	0.0
14/04/2023	23.3	18.6	8.6	13.0	13.1	12.2	22.3	0%	83%	13%	0%	0%	8%	0%	0.1	0.1
15/04/2023	26.6	24.3	13.2	12.9	13.6	20.4	19.3	17%	29%	8%	58%	63%	13%	0%	0.0	0.6
16/04/2023	44.8	16.1	15.6	27.0	27.8	17.1	26.0	17%	8%	0%	25%	33%	0%	17%	0.0	0.0
17/04/2023	25.8	29.8	20.0	18.5	17.8	21.7	28.4	33%	63%	21%	38%	25%	0%	29%	1.9	0.0
18/04/2023	24.5	35.0	26.2	16.1	14.6	32.5	36.3	0%	75%	13%	0%	4%	17%	0%	0.1	2.5
19/04/2023	27.5	30.9	25.5	21.4	22.0	27.4	31.7	29%	50%	8%	38%	33%	13%	17%	0.0	1.5
20/04/2023	17.9	17.4	16.4	12.7	12.2	17.3	21.9	0%	96%	8%	0%	0%	0%	0%	0.2	0.0
21/04/2023	20.8	22.3	12.9	13.2	15.3	16.7	26.9	0%	92%	8%	0%	0%	8%	0%	0.3	0.0
22/04/2023	18.3	27.5	10.7	12.5	12.8	15.9	27.8	0%	88%	0%	0%	0%	8%	0%	0.0	0.3
23/04/2023	13.4	20.1	11.1	8.2	9.4	16.9	17.1	13%	88%	8%	13%	8%	8%	17%	0.0	0.9
24/04/2023	14.8	22.8	14.4	9.7	11.3	16.9	23.8	0%	100%	17%	0%	0%	0%	0%	0.2	0.0
25/04/2023	22.5	29.1	18.9	19.6	21.4	23.4	23.9	0%	83%	25%	0%	0%	4%	0%	0.3	0.2
26/04/2023	20.1	24.1	15.3	11.7	-	21.2	17.7	13%	75%	33%	13%	4%	8%	13%	1.2	0.2
27/04/2023	26.4	39.5	15.6	15.2	10.5	23.1	21.7	4%	83%	8%	4%	4%	0%	8%	0.0	0.0
28/04/2023	36.8	24.3	22.7	18.3	14.3	29.3	25.6	17%	17%	0%	42%	54%	0%	13%	0.0	0.0
29/04/2023	41.0	20.4	17.8	22.7	26.2	18.1	33.2	25%	8%	4%	58%	71%	0%	0%	0.0	0.0
30/04/2023	7.1	7.9	4.2	7.5	9.9	4.4	14.1	0%	0%	0%	38%	92%	0%	0%	0.0	0.0
1/05/2023	10.9	9.2	7.3	9.9	10.9	5.7	24.2	0%	0%	0%	33%	83%	0%	0%	0.0	0.0
2/05/2023	16.5	12.2	10.3	14.2	13.5	8.2	38.6	0%	0%	0%	21%	83%	0%	0%	0.0	0.0
3/05/2023	27.4	14.0	11.7	22.4	19.6	11.0	46.2	0%	0%	0%	21%	38%	0%	0%	0.0	0.0
4/05/2023	33.1	29.0	15.2	19.0	20.5	17.9	19.2	21%	25%	13%	46%	42%	4%	17%	0.0	0.0
5/05/2023	42.5	37.7	13.2	-	28.0	15.9	24.8	29%	25%	4%	67%	63%	4%	17%	0.0	0.0
6/05/2023	43.4	28.8	18.8	-	21.9	15.2	28.0	17%	4%	0%	71%	71%	0%	13%	0.0	0.0



			24-hour	average leve	el (µg/m³)	_				Percentage	of time do	wnwind (%)	_	_	HVO North's e contribution t	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
7/05/2023	20.8	20.3	9.7	-	18.8	7.6	22.2	4%	0%	0%	38%	71%	0%	0%	0.0	0.0
8/05/2023	19.8	17.7	8.7	-	22.7	6.7	24.2	0%	0%	0%	29%	75%	0%	0%	0.0	0.0
9/05/2023	-	25.3	12.7	-	22.6	15.8	29.8	17%	33%	4%	63%	58%	8%	8%	0.0	0.7
10/05/2023	26.4	34.7	16.9	-	22.2	19.7	28.5	38%	50%	17%	42%	38%	4%	21%	0.9	0.0
11/05/2023	30.7	30.0	19.0	-	20.0	21.1	22.3	33%	58%	13%	29%	29%	8%	21%	0.2	0.4
12/05/2023	33.4	27.1	17.3	-	17.2	20.4	19.4	33%	33%	8%	58%	50%	13%	13%	0.5	0.3
13/05/2023	32.9	36.5	22.9	-	17.7	28.5	25.5	33%	71%	4%	38%	21%	17%	29%	0.4	2.4
14/05/2023	19.1	22.2	15.0	-	10.7	25.1	27.2	25%	67%	13%	21%	17%	25%	21%	0.5	4.6
15/05/2023	21.2	22.6	17.4	-	12.7	15.8	20.0	8%	50%	21%	21%	21%	38%	0%	0.2	1.0
16/05/2023	57.7	31.3	13.2	14.3	16.7	16.9	23.6	25%	38%	13%	46%	50%	4%	0%	0.4	0.0
17/05/2023	37.9	25.9	12.3	15.7	18.8	11.1	17.3	0%	92%	8%	0%	0%	0%	0%	0.0	0.0
18/05/2023	18.8	17.7	12.0	13.5	15.6	7.5	16.2	58%	21%	8%	54%	46%	13%	46%	0.6	0.0
19/05/2023	16.3	24.6	7.4	15.3	15.9	5.8	13.8	42%	0%	0%	96%	100%	0%	17%	0.0	0.0
20/05/2023	14.6	21.5	11.0	18.2	22.0	9.2	44.0	0%	0%	0%	33%	88%	0%	0%	0.0	0.0
21/05/2023	17.2	15.3	12.8	23.5	31.8	8.2	37.5	8%	0%	0%	21%	67%	0%	4%	0.0	0.0
22/05/2023	26.5	21.9	10.0	19.1	23.5	7.6	-	17%	0%	0%	71%	79%	0%	4%	0.0	0.0
23/05/2023	33.8	46.9	21.3	24.6	27.7	20.8	-	4%	29%	4%	58%	58%	4%	4%	0.5	0.0
24/05/2023	45.0	37.7	18.6	30.2	32.8	14.7	36.6	25%	0%	0%	83%	88%	0%	8%	0.0	0.0
25/05/2023	35.8	30.9	28.9	59.4	50.0	26.8	54.8	4%	0%	0%	63%	92%	0%	0%	0.0	0.0
26/05/2023	27.5	21.7	18.4	29.4	32.3	15.8	38.3	4%	25%	0%	33%	54%	0%	0%	0.0	0.0
27/05/2023	20.2	21.5	6.9	17.0	16.4	8.7	21.9	21%	0%	0%	63%	92%	0%	0%	0.0	0.0
28/05/2023	12.5	18.2	7.6	20.5	24.5	6.7	30.2	0%	0%	0%	54%	79%	0%	0%	0.0	0.0
29/05/2023	19.0	18.8	10.6	26.9	22.3	7.3	36.1	4%	0%	0%	42%	75%	0%	0%	0.0	0.0
30/05/2023	19.6	21.3	15.3	16.1	20.3	9.3	42.3	0%	0%	0%	46%	79%	0%	0%	0.0	0.0
31/05/2023	23.2	19.3	13.5	27.3	29.6	9.6	50.8	0%	0%	0%	25%	75%	0%	0%	0.0	0.0
1/06/2023	24.2	25.9	13.4	30.6	36.5	8.7	33.6	8%	0%	0%	42%	88%	0%	0%	0.0	0.0
2/06/2023	59.2	48.1	27.9	24.4	28.1	23.7	28.3	21%	63%	13%	33%	29%	8%	21%	0.0	0.0

			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution t	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
3/06/2023	42.2	26.4	18.5	16.3	21.5	19.2	41.5	4%	33%	0%	58%	63%	0%	8%	0.0	0.0
4/06/2023	16.1	28.6	25.2	14.3	17.0	22.9	36.6	0%	100%	4%	0%	0%	0%	0%	0.3	0.0
5/06/2023	13.5	27.6	21.6	13.4	13.5	21.7	26.3	0%	100%	4%	0%	0%	0%	0%	0.1	0.0
6/06/2023	16.6	30.8	25.8	12.2	9.6	22.5	13.5	0%	71%	13%	8%	8%	17%	0%	1.9	0.3
7/06/2023	30.3	34.1	17.1	12.5	11.3	21.7	16.6	25%	50%	17%	42%	42%	8%	25%	0.4	0.0
8/06/2023	17.0	16.1	7.4	11.0	12.5	8.1	19.9	25%	4%	0%	71%	88%	0%	13%	0.0	0.0
9/06/2023	13.3	13.2	8.0	16.7	18.7	7.8	21.5	0%	0%	0%	29%	88%	0%	0%	0.0	0.0
10/06/2023	46.8	19.9	9.3	18.0	16.2	10.6	22.5	13%	13%	0%	67%	83%	0%	0%	0.0	0.0
11/06/2023	53.1	36.9	12.5	22.1	23.0	16.9	27.0	21%	29%	4%	54%	54%	0%	17%	0.0	0.0
12/06/2023	56.4	35.5	11.5	20.0	16.5	17.5	33.4	17%	17%	0%	63%	67%	4%	0%	0.0	0.0
13/06/2023	33.4	21.3	7.1	14.3	15.9	9.3	25.6	29%	0%	0%	79%	96%	0%	29%	0.0	0.0
14/06/2023	12.8	10.8	7.4	14.4	9.5	5.7	17.2	0%	0%	0%	46%	71%	0%	0%	0.0	0.0
15/06/2023	17.4	15.7	7.2	12.9	11.0	6.1	24.8	0%	0%	0%	54%	96%	0%	0%	0.0	0.0
16/06/2023	37.8	16.1	8.8	16.8	18.3	8.7	20.8	13%	0%	0%	83%	79%	0%	8%	0.0	0.0
17/06/2023	24.4	21.7	8.9	17.1	16.1	11.8	17.1	0%	0%	0%	71%	88%	0%	0%	0.0	0.0
18/06/2023	25.7	16.8	8.9	31.4	22.7	8.9	24.7	0%	0%	0%	38%	71%	0%	0%	0.0	0.0
19/06/2023	16.9	16.8	7.8	17.8	20.7	6.2	29.8	0%	0%	0%	29%	92%	0%	0%	0.0	0.0
20/06/2023	-	15.1	11.5	15.6	17.5	7.8	25.0	17%	8%	0%	42%	58%	0%	21%	0.0	0.0
21/06/2023	-	46.8	23.2	28.1	29.0	27.8	24.4	33%	54%	4%	46%	46%	0%	0%	2.5	0.0
22/06/2023	-	38.7	28.0	18.5	36.1	32.6	40.8	25%	29%	17%	50%	58%	8%	17%	0.0	0.5
23/06/2023	-	12.1	7.3	3.1	13.1	6.7	23.5	0%	0%	0%	33%	63%	4%	0%	0.0	0.0
24/06/2023	-	10.7	4.7	13.9	13.0	5.0	29.8	8%	0%	0%	54%	92%	0%	4%	0.0	0.0
25/06/2023	-	16.2	6.4	16.8	12.6	6.2	37.6	4%	0%	0%	33%	79%	0%	0%	0.0	0.0
26/06/2023	-	19.0	8.8	20.0	18.4	7.2	50.7	0%	0%	0%	8%	83%	0%	0%	0.0	0.0
27/06/2023	-	16.9	10.3	20.0	15.1	8.5	44.2	0%	0%	0%	38%	96%	0%	0%	0.0	0.0
28/06/2023	-	12.9	9.3	16.4	18.6	6.6	26.0	0%	0%	0%	42%	88%	0%	0%	0.0	0.0
29/06/2023	-	1.5	6.3	15.5	11.5	3.0	31.6	0%	0%	0%	38%	96%	0%	0%	0.0	0.0



			24-hour	average leve	el (µg/m³)	-	-			Percentage	of time do	wnwind (%)		-	HVO North's e contribution t	estimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
30/06/2023	8.0	8.1	9.6	18.5	23.0	6.0	40.9	0%	0%	0%	71%	100%	0%	0%	0.0	0.0
1/07/2023	13.0	11.5	7.0	19.3	23.4	5.4	34.8	17%	0%	0%	83%	100%	0%	8%	0.0	0.0
2/07/2023	31.7	30.4	14.5	20.0	20.8	15.9	23.9	38%	42%	25%	46%	42%	13%	13%	0.9	0.2
3/07/2023	43.5	34.2	24.4	31.0	23.9	8.0	36.7	21%	58%	13%	29%	29%	8%	17%	0.9	0.0
4/07/2023	13.4	12.8	12.0	10.0	11.8	3.2	19.1	0%	33%	21%	8%	17%	38%	4%	0.0	0.1
5/07/2023	8.4	8.2	4.9	7.1	10.2	4.3	15.3	0%	0%	0%	8%	96%	0%	0%	0.0	0.0
6/07/2023	9.4	9.3	3.5	7.7	11.7	2.8	18.7	0%	0%	0%	29%	100%	0%	0%	0.0	0.0
7/07/2023	11.8	10.9	6.0	10.9	11.6	4.4	24.3	0%	0%	0%	13%	88%	0%	0%	0.0	0.0
8/07/2023	16.6	20.9	8.4	17.3	14.1	8.8	34.0	0%	0%	0%	4%	100%	0%	0%	0.0	0.0
9/07/2023	20.2	19.4	13.6	26.4	21.3	11.1	31.2	0%	0%	0%	21%	54%	0%	0%	0.0	0.0
10/07/2023	15.2	14.8	8.7	20.9	17.6	6.7	32.0	0%	0%	0%	38%	88%	0%	0%	0.0	0.0
11/07/2023	28.7	16.3	11.5	15.1	14.4	12.1	16.9	13%	0%	0%	58%	75%	17%	13%	0.0	1.9
12/07/2023	56.2	47.2	12.9	21.8	20.2	20.4	27.8	38%	50%	17%	54%	50%	4%	25%	0.0	0.0
13/07/2023	28.9	24.2	10.7	25.6	19.8	11.1	28.3	13%	0%	0%	79%	100%	0%	4%	0.0	0.0
14/07/2023	25.8	19.0	13.4	31.2	21.1	15.4	36.8	8%	0%	0%	58%	79%	0%	0%	0.0	0.0
15/07/2023	28.4	17.7	10.2	32.0	27.6	11.9	41.6	0%	0%	0%	58%	96%	0%	0%	0.0	0.0
16/07/2023	69.8	39.6	14.7	27.5	26.1	15.5	44.0	8%	67%	0%	25%	25%	0%	0%	0.0	0.0
17/07/2023	18.3	33.7	23.3	17.6	14.0	23.7	20.1	0%	75%	29%	0%	0%	17%	0%	1.3	0.3
18/07/2023	25.1	15.9	9.1	24.0	19.9	9.1	26.1	8%	8%	0%	54%	79%	4%	0%	0.0	0.0
19/07/2023	35.8	32.8	12.1	13.6	14.5	16.6	16.4	17%	33%	4%	46%	46%	8%	0%	0.0	0.0
20/07/2023	38.5	41.7	13.3	34.7	32.5	14.7	49.3	8%	0%	0%	58%	92%	4%	0%	0.0	0.0
21/07/2023	21.1	17.5	9.0	17.8	16.7	7.4	34.9	0%	4%	0%	46%	63%	0%	0%	0.0	0.0
22/07/2023	38.9	36.4	8.4	16.9	17.0	14.4	22.7	54%	25%	0%	50%	46%	17%	21%	0.0	0.0
23/07/2023	35.1	36.0	17.7	19.8	20.6	21.7	33.6	33%	46%	13%	46%	46%	0%	17%	0.5	0.0
24/07/2023	26.0	23.9	14.1	10.6	10.1	18.2	29.7	0%	63%	25%	0%	0%	29%	0%	1.0	0.3
25/07/2023	27.7	-	15.3	13.4	14.0	13.8	19.5	42%	46%	21%	46%	46%	17%	21%	1.8	0.0
26/07/2023	40.7	-	13.8	16.9	17.0	16.3	27.1	29%	17%	0%	67%	67%	17%	17%	0.0	3.1



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution to	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
27/07/2023	58.1	35.2	11.6	21.8	24.4	14.8	27.0	25%	0%	0%	75%	79%	13%	8%	0.0	2.0
28/07/2023	47.3	22.3	14.0	37.4	23.4	14.4	46.7	13%	0%	0%	46%	71%	0%	0%	0.0	0.0
29/07/2023	36.8	23.4	17.1	37.0	27.7	18.9	55.7	0%	0%	0%	75%	96%	0%	0%	0.0	0.0
30/07/2023	26.3	39.1	12.7	31.1	25.5	11.7	43.0	8%	0%	0%	38%	71%	0%	0%	0.0	0.0
31/07/2023	18.7	22.9	11.3	16.7	16.4	5.5	32.9	0%	0%	0%	71%	96%	0%	0%	0.0	0.0
1/08/2023	19.1	39.4	21.5	23.4	25.6	18.3	27.5	4%	38%	0%	50%	58%	0%	4%	0.0	0.0
2/08/2023	19.4	39.2	30.7	24.1	23.7	30.7	33.6	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
3/08/2023	31.6	35.5	13.3	12.8	-	15.7	22.5	25%	13%	4%	58%	54%	25%	21%	0.0	0.5
4/08/2023	56.7	37.4	17.5	28.9	24.0	20.5	36.4	13%	4%	0%	63%	71%	0%	4%	0.0	0.0
5/08/2023	58.9	37.0	14.4	45.1	38.6	17.9	40.9	21%	21%	4%	54%	67%	0%	4%	0.0	0.0
6/08/2023	22.5	37.6	21.4	15.3	16.1	18.1	23.1	0%	88%	33%	0%	0%	0%	0%	2.4	0.0
7/08/2023	20.5	37.2	24.2	14.3	12.4	23.9	17.8	4%	67%	33%	4%	4%	25%	0%	2.8	0.3
8/08/2023	21.3	29.0	24.4	12.8	10.3	25.5	17.5	4%	75%	21%	8%	8%	17%	4%	2.2	1.4
9/08/2023	47.8	24.4	17.3	23.4	22.1	19.0	28.9	25%	4%	0%	58%	58%	25%	25%	0.0	0.2
10/08/2023	59.6	30.7	15.2	49.7	40.3	14.1	47.1	17%	0%	0%	33%	58%	0%	0%	0.0	0.0
11/08/2023	52.4	26.2	19.8	29.0	27.0	12.4	25.2	46%	4%	0%	58%	58%	13%	25%	0.0	0.4
12/08/2023	27.2	28.9	17.4	38.6	32.8	16.8	39.9	0%	17%	0%	33%	50%	0%	0%	0.0	0.0
13/08/2023	33.8	31.5	17.3	23.6	20.2	19.2	30.2	8%	38%	13%	33%	38%	17%	8%	0.0	0.3
14/08/2023	12.1	14.4	10.2	12.0	11.4	11.9	12.1	4%	21%	0%	25%	58%	13%	4%	0.0	0.4
15/08/2023	11.6	16.6	7.8	8.8	7.0	7.9	8.9	0%	58%	29%	0%	4%	25%	0%	0.9	0.0
16/08/2023	16.4	21.7	14.4	9.3	9.0	14.9	14.6	21%	46%	8%	21%	17%	33%	17%	0.3	0.6
17/08/2023	26.1	17.3	10.0	22.1	13.3	8.4	25.4	21%	4%	0%	58%	67%	4%	21%	0.0	0.0
18/08/2023	9.5	7.9	6.1	10.4	7.6	5.6	17.7	0%	0%	0%	8%	54%	0%	0%	0.0	0.0
19/08/2023	12.5	11.8	7.7	13.6	14.4	6.2	39.0	0%	0%	0%	4%	88%	0%	0%	0.0	0.0
20/08/2023	20.9	15.8	6.7	16.8	15.5	9.9	21.9	21%	8%	0%	42%	46%	4%	21%	0.0	0.0
21/08/2023	28.4	23.2	9.0	16.8	13.6	5.4	23.7	25%	0%	0%	54%	67%	0%	8%	0.0	0.0
22/08/2023	-	26.6	16.1	30.6	24.6	15.3	30.2	13%	8%	4%	71%	71%	0%	4%	0.0	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution to	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
23/08/2023	-	21.3	18.8	22.2	19.3	13.4	31.6	4%	25%	13%	33%	54%	17%	0%	2.3	0.4
24/08/2023	26.3	36.6	26.8	19.6	13.3	30.1	22.9	0%	83%	33%	0%	0%	4%	0%	7.3	0.2
25/08/2023	-	32.4	25.2	29.3	25.0	20.6	29.3	17%	33%	13%	42%	38%	21%	8%	1.7	0.0
26/08/2023	18.8	34.0	27.0	19.4	16.6	29.8	28.0	21%	71%	4%	29%	25%	25%	17%	1.6	4.7
27/08/2023	14.8	35.7	17.2	17.7	13.7	21.8	22.3	29%	67%	13%	29%	25%	13%	13%	0.9	0.7
28/08/2023	-	32.9	26.1	21.6	14.8	24.7	22.6	17%	54%	4%	21%	17%	13%	17%	0.0	1.5
29/08/2023	-	35.8	18.6	29.9	27.1	31.4	31.5	25%	17%	0%	58%	63%	21%	13%	0.0	1.1
30/08/2023	-	33.5	26.6	40.8	36.2	18.6	47.4	8%	4%	0%	46%	63%	13%	8%	0.0	0.0
31/08/2023	12.9	18.3	10.9	13.7	10.2	11.9	14.7	13%	38%	8%	58%	63%	4%	4%	0.3	0.2
1/09/2023	15.3	23.1	15.8	14.8	13.0	17.9	21.7	4%	50%	42%	38%	42%	13%	4%	3.1	0.5
2/09/2023	29.5	37.5	20.7	16.8	13.9	22.9	25.6	21%	67%	25%	13%	8%	4%	21%	2.3	0.1
3/09/2023	28.6	33.1	20.4	13.3	-	20.3	29.5	17%	58%	13%	21%	21%	8%	4%	0.2	0.8
4/09/2023	26.6	36.2	27.5	18.9	-	32.9	33.4	8%	67%	25%	8%	8%	21%	4%	5.2	3.6
5/09/2023	26.4	22.7	14.5	34.8	18.4	8.9	34.1	17%	0%	0%	17%	46%	8%	17%	0.0	0.0
6/09/2023	35.3	41.4	27.3	32.4	30.8	27.1	-	17%	38%	4%	54%	58%	4%	8%	0.0	0.0
7/09/2023	42.6	36.3	46.0	41.3	34.3	29.6	53.5	50%	8%	8%	63%	58%	4%	38%	1.7	0.0
8/09/2023	12.7	9.5	7.2	15.8	10.6	5.7	17.3	4%	0%	0%	29%	63%	0%	0%	0.0	0.0
9/09/2023	15.9	17.8	9.0	15.2	12.6	9.1	20.8	0%	17%	0%	38%	67%	0%	0%	0.0	0.0
10/09/2023	25.2	36.1	17.1	30.0	18.2	16.8	21.9	38%	54%	25%	33%	29%	13%	33%	2.9	0.6
11/09/2023	36.1	32.7	23.7	28.7	18.4	31.4	31.0	17%	67%	29%	21%	13%	13%	13%	2.5	2.5
12/09/2023	35.4	37.8	29.2	36.2	29.2	27.3	30.6	33%	29%	4%	42%	33%	4%	21%	0.1	0.0
13/09/2023	40.2	40.4	31.7	37.5	31.1	32.4	38.1	21%	33%	8%	42%	33%	8%	8%	0.2	0.5
14/09/2023	45.4	42.4	49.1	30.0	22.6	38.8	37.0	13%	38%	25%	42%	42%	8%	4%	13.8	0.0
15/09/2023	77.1	43.5	28.6	36.0	31.4	21.2	37.7	13%	0%	0%	54%	67%	0%	4%	0.0	0.0
16/09/2023	49.1	36.1	18.3	49.3	31.1	21.2	59.2	4%	8%	0%	71%	92%	0%	0%	0.0	0.0
17/09/2023	59.5	43.4	25.5	53.0	32.3	27.4	51.9	13%	8%	4%	38%	71%	4%	4%	0.0	0.5
18/09/2023	108.9	46.1	39.5	52.5	48.0	33.3	50.6	13%	0%	0%	58%	71%	8%	4%	0.0	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution t	stimated max. o level (µg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
19/09/2023	71.1	56.2	35.0	53.9	38.1	28.3	93.6	25%	4%	0%	71%	83%	0%	17%	0.0	0.0
20/09/2023	49.2	41.5	32.5	73.9	54.2	32.0	93.5	25%	0%	0%	75%	88%	0%	21%	0.0	0.0
21/09/2023	59.0	37.6	28.0	52.6	32.3	30.4	48.3	4%	54%	13%	8%	13%	0%	4%	2.3	0.0
22/09/2023	30.1	36.9	28.1	28.3	15.9	20.4	42.1	0%	100%	8%	0%	0%	0%	0%	0.7	0.0
23/09/2023	35.1	33.5	35.7	24.9	15.1	30.1	35.4	17%	83%	8%	17%	13%	13%	17%	0.7	0.9
24/09/2023	23.6	33.1	33.3	33.5	14.6	29.3	30.0	0%	83%	4%	0%	0%	4%	0%	0.5	0.5
25/09/2023	54.4	29.5	35.0	33.9	20.5	22.3	37.7	25%	17%	0%	54%	75%	4%	17%	0.0	0.0
26/09/2023	54.5	44.6	44.6	50.7	34.6	28.6	44.4	4%	42%	13%	42%	42%	4%	4%	3.7	0.0
27/09/2023	28.2	31.6	23.6	36.7	25.9	27.4	43.8	8%	50%	0%	25%	29%	4%	8%	0.0	0.7
28/09/2023	19.4	25.2	19.1	16.5	11.4	15.1	20.3	0%	92%	0%	4%	4%	8%	0%	0.0	0.0
29/09/2023	29.5	31.6	19.6	25.0	16.8	17.0	29.3	4%	25%	4%	50%	63%	4%	0%	0.0	0.0
30/09/2023	55.5	30.5	28.5	30.4	21.9	34.1	35.5	29%	29%	8%	46%	42%	13%	13%	0.1	0.2
1/10/2023	61.4	42.9	33.0	64.6	48.6	28.5	74.7	33%	4%	0%	75%	88%	0%	17%	0.0	0.0
2/10/2023	49.5	65.4	63.6	-	44.7	52.0	63.5	4%	88%	4%	4%	4%	8%	4%	2.0	0.3
3/10/2023	46.6	41.0	26.4	-	33.8	26.0	63.3	13%	0%	4%	63%	88%	8%	8%	0.3	0.6
4/10/2023	37.6	21.6	25.7	-	30.8	27.3	55.8	21%	0%	0%	58%	79%	0%	13%	0.0	0.0
5/10/2023	11.8	8.3	7.4	-	11.1	2.7	17.5	0%	0%	0%	8%	67%	0%	0%	0.0	0.0
6/10/2023	18.0	24.0	18.3	17.7	17.5	13.7	22.9	4%	50%	8%	42%	42%	13%	4%	0.3	0.2
7/10/2023	22.7	22.5	18.1	22.8	13.8	20.2	21.9	0%	100%	21%	0%	0%	0%	0%	0.5	0.0
8/10/2023	16.5	35.5	21.5	23.4	11.4	19.9	20.6	4%	88%	21%	4%	4%	13%	4%	1.4	1.4
9/10/2023	-	27.2	20.4	18.5	-	20.0	27.4	4%	25%	0%	58%	63%	4%	0%	0.0	0.0
10/10/2023	37.0	36.3	35.1	27.3	-	32.3	38.0	8%	63%	21%	13%	13%	21%	8%	4.9	1.6
11/10/2023	31.3	35.8	38.9	24.5	23.9	31.3	42.6	4%	58%	4%	13%	13%	13%	4%	1.2	0.7
12/10/2023	47.9	36.3	33.8	39.5	37.1	24.3	45.6	25%	0%	4%	58%	79%	4%	17%	0.0	0.0
13/10/2023	30.9	16.9	19.4	24.3	16.6	9.9	20.6	0%	13%	4%	29%	38%	4%	0%	0.0	0.0
14/10/2023	30.0	25.5	16.3	36.9	26.1	8.7	46.4	8%	0%	0%	38%	71%	4%	4%	0.0	0.0
15/10/2023	49.2	28.2	20.1	50.1	39.5	21.7	38.9	13%	17%	0%	25%	29%	0%	4%	0.0	0.0



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution to	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
16/10/2023	71.7	32.8	34.9	54.4	35.0	23.2	54.8	8%	17%	0%	29%	38%	4%	8%	0.0	0.8
17/10/2023	46.1	37.8	27.9	27.6	25.5	16.6	40.5	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
18/10/2023	-	27.1	30.0	26.5	11.9	22.8	27.2	0%	83%	38%	0%	0%	8%	0%	3.0	0.2
19/10/2023	4.9	34.1	40.9	25.5	18.4	24.3	33.4	0%	100%	8%	0%	0%	0%	0%	3.5	0.0
20/10/2023	37.6	35.8	45.7	32.9	30.5	37.1	49.7	25%	29%	13%	33%	29%	33%	8%	1.3	5.0
21/10/2023	40.4	38.0	50.7	37.8	30.5	35.5	55.1	0%	25%	25%	17%	25%	33%	8%	2.5	0.3
22/10/2023	59.3	33.2	26.7	50.3	40.5	27.1	69.7	4%	8%	0%	21%	29%	4%	8%	0.0	0.1
23/10/2023	34.3	43.6	43.9	45.9	32.6	26.5	55.1	13%	13%	4%	29%	46%	8%	0%	0.0	3.1
24/10/2023	64.0	52.4	37.2	48.3	47.7	28.9	52.1	33%	4%	0%	79%	83%	17%	13%	0.0	0.4
25/10/2023	60.2	51.2	49.6	81.9	57.0	37.0	64.9	0%	29%	0%	21%	33%	0%	0%	0.0	0.0
26/10/2023	5.7	21.5	18.0	16.3	17.0	13.2	28.0	0%	100%	8%	0%	0%	0%	0%	0.1	0.0
27/10/2023	9.8	11.8	8.3	6.6	9.1	8.2	18.7	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
28/10/2023	15.8	19.3	12.0	8.6	10.4	11.9	20.3	0%	92%	13%	0%	0%	4%	0%	0.6	0.0
29/10/2023	28.5	16.6	15.8	22.3	21.1	23.6	21.6	17%	33%	0%	29%	33%	21%	17%	0.0	0.6
30/10/2023	55.5	29.6	21.6	40.9	34.5	26.7	54.9	21%	0%	0%	88%	100%	0%	4%	0.0	0.0
31/10/2023	50.8	49.1	34.5	45.2	45.5	28.2	73.8	4%	33%	4%	25%	46%	0%	0%	5.4	0.0
1/11/2023	22.0	35.9	39.7	21.7	22.8	27.0	35.6	0%	100%	21%	0%	0%	0%	0%	4.1	0.0
2/11/2023	20.8	28.9	37.8	19.9	16.7	22.1	35.5	0%	96%	21%	0%	0%	0%	0%	6.4	0.0
3/11/2023	21.4	32.2	34.0	17.1	14.8	18.0	40.7	0%	96%	25%	0%	0%	0%	0%	9.0	0.0
4/11/2023	22.7	36.8	22.8	19.1	15.5	21.6	38.3	0%	96%	21%	0%	0%	4%	0%	1.2	0.1
5/11/2023	11.1	26.6	20.1	10.4	9.4	14.1	24.1	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
6/11/2023	15.4	27.0	22.6	11.2	13.6	18.6	33.2	0%	100%	17%	0%	0%	0%	0%	2.6	0.0
7/11/2023	19.7	30.7	27.7	12.5	11.4	21.9	28.0	17%	79%	4%	17%	13%	17%	4%	0.4	0.5
8/11/2023	33.0	22.6	29.2	25.1	24.2	23.0	32.0	17%	8%	17%	33%	42%	38%	8%	5.2	1.7
9/11/2023	30.0	17.9	33.8	20.1	27.1	26.7	29.6	4%	33%	13%	17%	21%	33%	8%	0.6	0.2
10/11/2023	26.2	22.4	18.7	18.1	14.8	18.7	23.0	4%	54%	0%	29%	38%	0%	8%	0.0	0.0
11/11/2023	30.9	21.4	22.1	22.4	20.1	21.6	32.4	13%	13%	17%	46%	71%	8%	4%	0.0	0.2



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)		_	HVO North's e contribution to	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
12/11/2023	39.7	40.3	25.1	59.5	41.3	25.8	57.8	0%	13%	8%	21%	42%	4%	0%	3.2	1.7
13/11/2023	25.7	37.2	43.7	37.4	25.8	30.8	39.0	0%	100%	29%	0%	0%	0%	0%	4.2	0.0
14/11/2023	38.7	40.8	40.3	41.2	31.3	30.9	52.0	8%	42%	8%	17%	38%	8%	4%	0.9	0.0
15/11/2023	36.1	35.2	44.5	43.2	31.4	27.0	36.1	8%	50%	21%	25%	29%	0%	0%	6.7	0.0
16/11/2023	30.3	33.7	36.5	27.6	-	22.5	31.9	0%	63%	13%	17%	21%	0%	4%	0.4	0.0
17/11/2023	21.9	21.7	16.5	16.3	12.9	14.5	22.9	0%	92%	29%	0%	0%	4%	0%	2.4	0.0
18/11/2023	15.6	25.1	20.8	15.9	10.9	17.2	34.5	0%	92%	17%	0%	0%	0%	0%	1.3	0.0
19/11/2023	27.4	35.1	34.3	26.7	18.4	33.1	55.1	4%	54%	17%	4%	4%	42%	8%	1.9	2.5
20/11/2023	19.0	26.7	32.9	21.4	18.2	21.6	36.1	0%	63%	33%	13%	13%	8%	0%	5.1	0.9
21/11/2023	27.0	21.2	26.4	19.4	16.3	23.5	34.3	4%	42%	21%	4%	0%	46%	13%	0.8	1.7
22/11/2023	19.8	28.5	23.9	19.8	14.9	18.9	41.3	0%	88%	58%	0%	0%	0%	0%	4.2	0.0
23/11/2023	20.5	29.4	29.2	21.1	12.8	19.8	41.2	0%	100%	17%	0%	0%	0%	0%	2.2	0.0
24/11/2023	14.4	-	13.8	13.2	11.1	9.4	25.9	0%	100%	8%	0%	0%	0%	0%	0.1	0.0
25/11/2023	8.0	-	7.9	6.4	7.5	5.0	14.6	17%	54%	4%	13%	29%	0%	8%	0.0	0.0
26/11/2023	13.3	-	11.6	18.8	14.3	5.8	21.7	4%	0%	0%	29%	67%	0%	4%	0.0	0.0
27/11/2023	24.2	-	18.6	23.4	21.4	15.7	38.5	13%	50%	0%	42%	38%	4%	4%	0.0	0.0
28/11/2023	18.7	20.9	19.1	18.0	19.2	16.7	33.9	0%	100%	0%	0%	0%	0%	0%	0.0	0.0
29/11/2023	15.9	15.9	17.1	11.0	12.8	14.7	17.5	8%	63%	4%	17%	21%	0%	8%	0.3	0.0
30/11/2023	14.9	11.2	8.1	25.7	11.2	7.6	28.0	0%	0%	0%	0%	29%	0%	0%	0.0	0.0
1/12/2023	18.5	17.1	16.2	20.2	19.8	14.6	30.5	0%	21%	4%	25%	54%	0%	0%	0.8	0.0
2/12/2023	18.4	11.8	11.5	14.7	11.1	13.3	18.7	0%	25%	4%	25%	38%	0%	0%	0.0	0.0
3/12/2023	28.4	22.7	15.6	20.3	17.7	15.6	20.5	8%	50%	0%	33%	38%	0%	0%	0.0	0.0
4/12/2023	18.9	26.3	31.6	17.3	13.9	21.0	36.3	0%	100%	13%	0%	0%	0%	0%	1.9	0.0
5/12/2023	31.7	27.3	21.7	27.2	29.9	27.1	40.0	17%	13%	0%	63%	71%	0%	4%	0.0	0.0
6/12/2023	45.8	56.3	45.1	51.2	46.1	45.7	52.8	0%	58%	21%	29%	29%	4%	0%	5.4	2.8
7/12/2023	32.3	56.0	-	39.8	39.8	44.7	42.3	4%	58%	21%	21%	25%	21%	4%	-	0.7
8/12/2023	34.7	26.2	-	42.1	38.2	27.8	42.7	17%	8%	8%	58%	71%	8%	13%	-	0.1



			24-hour	average leve	el (µg/m³)					Percentage	of time do	wnwind (%)			HVO North's e contribution t	stimated max. ο level (μg/m³)
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Wandewoi
9/12/2023	33.8	51.9	16.2	43.4	31.5	27.6	51.3	8%	13%	4%	25%	54%	0%	0%	0.0	0.0
10/12/2023	26.0	37.8	11.8	32.3	20.9	23.6	57.4	0%	100%	8%	0%	0%	0%	0%	0.0	0.0
11/12/2023	35.5	57.2	22.8	50.8	35.1	41.3	55.5	0%	75%	54%	0%	0%	17%	0%	0.0	0.1
12/12/2023	20.3	35.1	9.2	29.5	18.3	24.8	43.7	0%	92%	25%	0%	0%	0%	0%	0.0	0.0
13/12/2023	38.4	46.8	14.6	46.2	37.8	33.8	47.1	21%	54%	17%	17%	17%	17%	17%	0.0	0.5
14/12/2023	44.8	35.4	14.1	51.0	43.8	19.5	53.5	0%	8%	4%	8%	38%	4%	0%	0.0	0.0
15/12/2023	31.6	52.4	21.8	57.4	42.5	54.4	50.2	0%	88%	46%	0%	0%	8%	0%	0.0	1.0
16/12/2023	30.4	42.9	13.0	56.6	31.8	34.5	58.4	0%	21%	4%	17%	46%	13%	0%	0.0	1.0
17/12/2023	25.2	54.5	15.4	61.9	30.9	36.5	54.9	0%	100%	21%	0%	0%	0%	0%	0.0	0.0
18/12/2023	33.8	61.3	20.4	52.6	37.3	43.3	57.7	8%	79%	8%	8%	0%	13%	8%	0.1	4.8
19/12/2023	54.5	47.8	34.5	56.7	54.5	51.4	60.1	13%	4%	13%	42%	46%	25%	13%	0.0	3.9
20/12/2023	19.6	14.4	10.8	12.0	15.1	10.3	15.7	4%	63%	17%	4%	8%	21%	4%	0.0	0.0
21/12/2023	17.6	14.9	4.1	10.4	12.2	10.1	26.8	0%	96%	13%	0%	0%	4%	0%	0.0	0.0
22/12/2023	23.8	32.6	7.0	29.4	20.8	23.8	29.9	0%	96%	25%	0%	0%	0%	0%	0.0	0.0
23/12/2023	28.0	24.7	-	16.4	13.2	21.7	23.6	13%	50%	38%	17%	17%	25%	13%	-	0.5
24/12/2023	14.1	10.2	-	12.2	9.8	10.3	12.4	0%	63%	21%	8%	8%	25%	4%	-	0.0
25/12/2023	13.2	15.2	-	17.2	14.1	12.9	14.5	0%	88%	4%	0%	0%	13%	0%	-	0.0
26/12/2023	18.0	16.4	-	20.9	15.0	18.4	18.5	21%	38%	13%	33%	25%	25%	17%	-	0.5
27/12/2023	20.2	20.6	6.8	24.6	14.8	13.7	24.4	4%	21%	0%	25%	38%	0%	4%	0.0	0.0
28/12/2023	17.0	20.0	7.1	21.8	15.2	13.3	21.0	0%	21%	0%	38%	58%	0%	0%	0.0	0.0
29/12/2023	24.5	22.6	7.7	28.9	20.0	13.3	31.8	13%	17%	0%	38%	67%	0%	4%	0.0	0.0
30/12/2023	21.6	34.7	7.6	27.5	14.4	19.1	27.9	0%	54%	4%	8%	21%	4%	0%	0.0	0.2
31/12/2023	16.0	31.0	7.4	38.7	18.0	19.4	25.0	0%	92%	0%	0%	0%	0%	0%	0.0	0.0

- No data

Note for this annual review, TEOM data time was assessed per Australian Eastern Standard Time (AEST) as used by DCCEEW, however some minor differences arise with the operational data which uses Australian Eastern Daylight Time (AEDT). Some minor differences also arise as HVO collects data in real-time from DCCEEW monitors using a separate HVO logger which may result in minor additional time shift effect.



			24-hour a	iverage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (୨	%)		HVO So	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
1/01/2023	13.8	26.2	24.7	15.1	12.1	-	23.2	0%	0%	83%	0%	0%	100%	0%	8.0	0.0	0.0	-	0.0
2/01/2023	15.3	29.2	30.5	14.5	14.6	-	25.4	0%	0%	67%	0%	0%	92%	0%	9.2	0.0	0.0	-	0.0
3/01/2023	30.1	44.1	40.9	26.3	26.4	-	39.5	21%	0%	50%	13%	0%	67%	21%	4.4	0.0	0.0	-	0.9
4/01/2023	23.5	39.3	31.5	18.6	18.8	23.3	30.4	4%	4%	67%	4%	0%	88%	4%	9.2	0.0	0.0	4.0	0.4
5/01/2023	20.2	15.5	10.2	10.2	11.9	10.0	23.9	0%	4%	38%	0%	0%	100%	0%	0.1	0.0	0.0	0.0	0.0
6/01/2023	18.6	13.1	7.1	15.0	15.0	7.6	7.4	0%	29%	13%	0%	0%	88%	0%	0.0	0.0	0.0	0.0	0.0
7/01/2023	24.0	14.5	9.7	14.3	14.4	11.5	16.5	0%	8%	42%	0%	0%	96%	0%	0.2	0.0	0.0	0.9	0.0
8/01/2023	24.1	26.0	18.9	16.4	17.4	18.3	23.5	0%	0%	58%	0%	0%	100%	0%	3.2	0.0	0.0	2.4	0.0
9/01/2023	35.7	41.3	36.3	26.0	27.2	26.9	26.0	33%	4%	42%	21%	0%	63%	33%	8.6	2.2	0.0	5.6	1.9
10/01/2023	26.8	31.8	29.5	15.5	13.7	24.0	25.9	8%	13%	58%	8%	4%	79%	8%	6.7	0.1	0.0	5.9	0.0
11/01/2023	25.7	34.2	30.2	20.8	19.9	25.3	30.1	0%	0%	83%	0%	0%	100%	0%	9.9	0.0	0.0	7.0	0.0
12/01/2023	25.1	39.1	38.3	22.6	18.2	32.7	36.2	0%	0%	79%	0%	0%	96%	0%	11.9	0.0	0.0	8.0	0.0
13/01/2023	22.3	33.4	34.1	18.1	17.1	22.3	27.7	0%	0%	92%	0%	0%	100%	0%	13.3	0.0	0.0	3.3	0.0
14/01/2023	11.9	22.7	23.7	12.8	10.8	19.2	21.7	0%	0%	71%	0%	0%	100%	0%	9.1	0.0	0.0	5.1	0.0
15/01/2023	25.0	29.5	28.4	22.1	20.7	28.2	32.7	29%	0%	38%	13%	0%	58%	25%	3.8	1.0	0.0	5.2	3.2
16/01/2023	17.7	36.5	28.5	18.2	14.1	21.0	23.3	0%	0%	100%	0%	0%	100%	0%	10.5	0.0	0.0	4.2	0.0
17/01/2023	12.8	27.1	28.7	13.5	11.1	17.6	23.9	0%	0%	58%	0%	0%	88%	0%	8.0	0.0	0.0	3.0	0.0
18/01/2023	38.1	38.1	35.6	30.3	29.0	29.6	29.3	29%	21%	8%	8%	0%	25%	29%	1.7	0.0	0.0	1.1	2.0
19/01/2023	11.0	12.6	8.8	9.4	11.7	9.5	12.5	13%	0%	25%	29%	17%	58%	4%	0.6	0.5	0.3	0.4	0.0
20/01/2023	16.3	21.1	14.5	12.3	13.3	13.6	22.2	0%	0%	88%	0%	0%	100%	0%	1.1	0.0	0.0	1.1	0.0
21/01/2023	19.3	25.1	19.4	13.4	14.0	18.9	25.4	0%	0%	92%	0%	0%	100%	0%	4.0	0.0	0.0	3.5	0.0
22/01/2023	14.9	14.7	10.8	10.2	10.6	11.4	22.2	0%	0%	63%	0%	0%	100%	0%	0.8	0.0	0.0	1.0	0.0
23/01/2023	21.0	23.2	16.5	14.8	16.9	18.3	25.6	0%	8%	46%	0%	0%	75%	0%	1.8	0.0	0.0	2.4	0.0
24/01/2023	26.7	31.9	20.2	18.3	18.7	26.0	54.6	0%	4%	50%	0%	0%	79%	0%	4.4	0.0	0.0	3.6	0.0
25/01/2023	26.7	36.3	27.8	22.0	23.9	28.3	33.5	8%	4%	50%	8%	8%	67%	4%	3.8	0.3	0.0	6.3	0.0

Table B-3: 24-hour average PM₁₀ TEOM levels, percent time downwind and estimated contributions – HVO South



			24-hour a	iverage lev	vel (µg/m³	[;])			Pe	ercentage	of time do	wnwind (୨	%)		HVO S	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
26/01/2023	36.4	29.7	24.2	23.3	22.3	20.3	31.5	50%	0%	13%	46%	4%	33%	38%	0.9	1.8	0.0	0.8	1.4
27/01/2023	26.3	38.3	32.9	29.6	25.7	30.4	50.3	0%	0%	79%	0%	0%	100%	0%	7.1	0.0	0.0	4.8	0.0
28/01/2023	31.6	31.5	28.9	21.5	19.2	31.2	38.2	25%	0%	33%	21%	8%	54%	21%	0.8	0.4	0.0	4.9	0.9
29/01/2023	29.4	32.5	24.3	18.1	19.5	19.5	23.9	25%	4%	21%	29%	17%	29%	21%	2.9	0.7	0.9	1.3	1.0
30/01/2023	15.0	15.2	11.1	13.0	-	12.0	18.8	17%	4%	17%	13%	8%	38%	17%	0.4	0.1	-	0.5	1.3
31/01/2023	17.3	-	11.8	15.2	12.6	14.7	18.7	0%	8%	50%	0%	0%	67%	0%	1.0	0.0	0.0	1.1	0.0
1/02/2023	30.3	19.6	16.9	18.6	19.3	22.4	23.0	25%	0%	46%	4%	4%	54%	25%	3.0	0.0	0.0	0.9	1.9
2/02/2023	27.1	17.2	14.7	40.0	-	15.6	38.4	29%	0%	29%	63%	38%	29%	21%	0.1	21.9	-	0.2	6.8
3/02/2023	35.1	23.4	17.4	59.4	-	13.3	39.8	29%	0%	0%	96%	71%	0%	21%	0.0	32.6	-	0.0	2.5
4/02/2023	37.6	19.5	11.6	38.8	16.7	8.4	35.1	33%	0%	0%	92%	67%	0%	29%	0.0	19.7	0.7	0.0	4.6
5/02/2023	31.9	43.7	24.6	35.1	32.2	24.8	42.8	50%	0%	25%	33%	4%	38%	50%	3.8	8.4	0.4	2.8	8.5
6/02/2023	25.2	46.3	-	24.4	23.4	27.8	55.5	0%	0%	71%	4%	4%	79%	0%	-	0.0	0.0	2.9	0.0
7/02/2023	-	30.7	31.3	22.8	17.5	23.9	36.3	0%	0%	92%	0%	0%	100%	0%	8.8	0.0	0.0	3.4	0.0
8/02/2023	-	29.8	25.7	21.0	16.2	21.6	35.0	0%	0%	92%	0%	0%	100%	0%	4.9	0.0	0.0	1.7	0.0
9/02/2023	24.5	20.8	13.6	12.8	13.0	13.5	19.5	0%	13%	29%	0%	0%	54%	0%	0.6	0.0	0.0	0.2	0.0
10/02/2023	40.3	25.0	17.3	17.5	16.7	16.2	21.8	42%	0%	13%	25%	8%	33%	50%	1.4	0.5	0.3	0.5	2.4
11/02/2023	59.0	30.9	13.7	28.0	23.2	19.9	31.5	63%	4%	8%	63%	25%	8%	58%	0.0	7.6	1.6	0.4	7.4
12/02/2023	60.1	39.7	27.7	38.0	36.7	25.5	37.3	46%	0%	33%	38%	8%	38%	46%	1.7	7.0	0.2	2.0	3.7
13/02/2023	33.8	37.9	33.3	28.1	26.0	28.0	36.6	0%	0%	92%	0%	0%	100%	0%	4.1	0.0	0.0	1.2	0.0
14/02/2023	27.3	28.2	19.5	17.8	-	16.9	31.4	0%	0%	79%	0%	0%	96%	0%	1.2	0.0	-	0.2	0.0
15/02/2023	27.5	38.7	-	13.8	-	21.9	35.6	0%	0%	58%	0%	0%	100%	0%	-	0.0	-	4.2	0.0
16/02/2023	45.5	46.0	29.0	16.1	-	32.8	32.5	21%	0%	54%	13%	0%	67%	21%	7.0	1.9	-	10.4	4.6
17/02/2023	43.4	40.2	38.8	19.5	19.6	31.2	49.2	21%	0%	42%	0%	0%	63%	29%	7.1	0.0	0.0	7.6	11.9
18/02/2023	57.3	32.2	26.7	29.8	35.9	37.7	36.1	42%	13%	8%	50%	21%	21%	38%	1.9	3.0	1.2	1.7	4.0
19/02/2023	-	33.2	24.7	24.1	24.7	21.7	35.6	4%	0%	79%	8%	4%	88%	0%	1.6	0.1	0.0	0.2	0.0
20/02/2023	-	38.0	25.9	21.9	21.1	26.2	43.4	25%	0%	46%	13%	0%	63%	21%	4.3	0.0	0.0	3.7	3.5
21/02/2023	43.2	36.9	30.0	22.4	19.9	25.6	38.5	4%	4%	58%	8%	4%	67%	0%	5.3	0.2	0.0	3.2	0.0



			24-hour a	iverage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (%	%)		HVO So	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
22/02/2023	12.9	8.3	6.2	8.7	7.7	5.4	9.1	0%	25%	50%	0%	0%	100%	0%	0.1	0.0	0.0	0.3	0.0
23/02/2023	20.2	20.8	-	14.5	13.9	13.3	22.4	0%	0%	92%	0%	0%	100%	0%	-	0.0	0.0	0.5	0.0
24/02/2023	19.8	18.2	16.0	11.3	11.7	17.0	23.7	0%	0%	71%	0%	0%	96%	0%	2.1	0.0	0.0	2.5	0.0
25/02/2023	20.6	25.2	18.9	11.7	11.8	23.0	26.1	13%	0%	33%	0%	0%	67%	21%	2.5	0.0	0.0	6.5	1.7
26/02/2023	41.8	18.7	15.7	20.7	18.7	28.1	25.7	38%	4%	0%	38%	21%	8%	42%	0.0	2.0	0.7	4.5	1.0
27/02/2023	47.8	32.3	21.6	29.7	30.4	24.3	37.8	42%	0%	29%	38%	4%	33%	42%	0.7	3.2	0.2	0.2	6.4
28/02/2023	22.9	26.2	24.7	18.3	17.2	19.9	32.0	0%	0%	75%	0%	0%	96%	0%	3.7	0.0	0.0	1.2	0.0
1/03/2023	28.7	25.6	21.0	19.1	19.5	19.0	28.2	29%	0%	38%	25%	8%	42%	38%	1.2	0.6	0.5	3.5	5.0
2/03/2023	20.6	24.3	26.0	16.7	12.3	16.7	22.8	0%	0%	79%	0%	0%	100%	0%	6.7	0.0	0.0	2.1	0.0
3/03/2023	18.8	28.2	22.7	14.6	13.2	17.7	25.7	0%	0%	88%	0%	0%	100%	0%	7.3	0.0	0.0	2.2	0.0
4/03/2023	20.4	28.7	18.6	14.7	12.1	15.7	29.8	0%	0%	75%	0%	0%	100%	0%	3.0	0.0	0.0	1.5	0.0
5/03/2023	30.3	35.9	23.6	35.6	25.4	23.7	26.7	38%	4%	17%	21%	4%	38%	38%	0.0	1.7	0.0	3.0	4.0
6/03/2023	40.6	33.0	25.6	58.7	32.3	27.4	54.1	83%	0%	0%	92%	17%	0%	63%	0.0	28.3	1.7	0.0	15.6
7/03/2023	44.5	35.1	22.7	65.1	42.9	18.6	63.1	42%	0%	0%	96%	58%	0%	29%	0.0	33.1	5.9	0.0	14.8
8/03/2023	39.9	43.3	29.2	66.8	45.3	23.0	56.5	33%	0%	0%	96%	63%	0%	29%	0.0	32.5	5.0	0.0	6.6
9/03/2023	41.9	43.5	36.0	41.0	40.0	32.2	46.9	54%	4%	0%	71%	21%	21%	42%	0.0	5.6	0.5	1.2	4.3
10/03/2023	35.1	53.1	36.0	24.2	23.9	30.1	45.2	13%	4%	54%	0%	0%	79%	13%	10.2	0.0	0.0	6.3	0.0
11/03/2023	30.3	35.0	24.5	25.1	26.6	20.9	29.8	42%	8%	4%	54%	25%	13%	38%	0.0	1.6	1.8	0.4	3.0
12/03/2023	26.8	33.6	22.3	23.4	22.7	18.7	31.7	4%	4%	58%	21%	17%	75%	4%	1.8	1.0	0.1	0.5	0.5
13/03/2023	22.7	18.9	18.5	15.5	17.1	14.5	-	0%	0%	92%	0%	0%	100%	0%	1.4	0.0	0.0	0.3	-
14/03/2023	19.2	21.7	15.1	13.6	15.0	12.9	-	0%	4%	67%	0%	0%	100%	0%	0.8	0.0	0.0	0.2	-
15/03/2023	28.3	30.9	23.9	17.9	19.2	23.9	40.2	25%	0%	38%	13%	0%	50%	33%	2.0	0.7	0.0	3.4	6.9
16/03/2023	40.4	24.3	26.4	34.2	28.2	17.1	36.3	63%	0%	0%	83%	33%	0%	67%	0.0	11.5	1.5	0.0	9.8
17/03/2023	33.2	48.1	35.3	33.5	38.9	38.4	46.6	46%	0%	46%	29%	0%	54%	46%	4.2	1.2	0.0	6.9	3.2
18/03/2023	38.4	59.1	35.1	26.3	29.6	42.5	35.1	25%	4%	25%	25%	8%	42%	29%	2.5	0.4	0.0	8.9	2.7
19/03/2023	53.9	53.7	31.7	35.8	30.4	38.6	38.0	46%	8%	8%	42%	8%	13%	46%	0.0	3.0	3.0	3.1	2.0
20/03/2023	39.6	56.6	37.5	33.3	30.5	40.3	60.7	0%	0%	88%	0%	0%	100%	0%	1.6	0.0	0.0	6.2	0.0



			24-hour a	verage lev	∕el (µg/m³)			Pe	ercentage	of time do	wnwind (%	%)		HVO So	outh's estim	ated max. c (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
21/03/2023	21.5	28.9	25.0	16.7	17.8	25.5	44.0	0%	0%	100%	0%	0%	100%	0%	3.9	0.0	0.0	2.4	0.0
22/03/2023	29.2	37.7	24.1	18.4	18.7	24.9	33.8	0%	0%	54%	0%	0%	96%	0%	1.5	0.0	0.0	4.0	0.0
23/03/2023	19.6	-	16.0	30.5	18.6	18.4	28.7	46%	0%	8%	71%	29%	13%	38%	0.0	13.7	1.3	0.8	2.1
24/03/2023	-	21.5	14.4	11.8	16.5	15.0	21.8	13%	0%	67%	13%	8%	71%	4%	1.4	0.3	0.5	1.6	0.3
25/03/2023	-	11.5	13.8	6.3	8.6	18.4	31.4	0%	0%	100%	0%	0%	100%	0%	2.0	0.0	0.0	4.5	0.0
26/03/2023	-	16.7	19.2	8.9	10.8	27.1	39.0	0%	0%	83%	0%	0%	100%	0%	3.2	0.0	0.0	9.7	0.0
27/03/2023	-	16.6	9.8	8.6	11.0	14.1	13.1	63%	0%	13%	54%	0%	17%	67%	0.3	0.1	0.0	1.2	1.7
28/03/2023	17.2	17.7	12.3	12.1	16.2	14.4	-	42%	8%	25%	38%	4%	42%	42%	0.4	1.2	0.2	1.5	-
29/03/2023	14.0	8.5	9.5	11.1	13.1	10.1	15.4	79%	0%	0%	92%	21%	0%	54%	0.0	2.1	0.3	0.0	3.4
30/03/2023	10.4	4.2	8.0	13.1	14.5	7.0	12.2	29%	0%	0%	100%	71%	0%	21%	0.0	5.2	6.4	0.0	1.2
31/03/2023	43.2	12.8	9.2	15.5	15.5	7.5	18.3	50%	0%	0%	83%	42%	0%	38%	0.0	3.0	0.4	0.0	2.4
1/04/2023	26.1	24.3	10.8	16.7	17.1	12.0	24.7	46%	0%	33%	33%	0%	42%	50%	0.0	2.1	0.0	0.8	3.6
2/04/2023	28.3	-	13.0	14.9	13.3	13.4	27.1	0%	0%	58%	0%	0%	96%	0%	0.4	0.0	0.0	0.4	0.0
3/04/2023	15.5	23.5	17.6	11.2	10.6	21.2	45.1	0%	0%	71%	0%	0%	100%	0%	2.2	0.0	0.0	3.6	0.0
4/04/2023	23.7	21.4	14.8	10.5	9.7	18.1	30.3	8%	4%	71%	4%	0%	83%	8%	1.3	0.0	0.0	2.0	0.0
5/04/2023	30.5	29.1	12.6	15.4	14.9	19.9	20.9	33%	0%	33%	8%	8%	71%	33%	0.5	0.0	0.5	2.9	0.6
6/04/2023	28.1	34.3	14.7	31.3	11.0	22.0	26.4	29%	4%	38%	4%	0%	71%	25%	0.7	0.0	0.0	2.8	1.6
7/04/2023	22.8	19.4	9.9	13.8	10.6	14.6	21.1	63%	0%	8%	67%	13%	21%	54%	0.0	3.3	0.0	3.3	7.3
8/04/2023	21.3	15.9	10.6	21.3	17.0	11.8	48.4	4%	0%	0%	100%	96%	0%	0%	0.0	3.4	1.0	0.0	0.0
9/04/2023	16.4	12.8	9.3	19.4	19.7	9.1	38.6	0%	0%	0%	100%	100%	0%	0%	0.0	4.1	4.9	0.0	0.0
10/04/2023	16.6	10.1	8.4	16.7	11.4	7.6	24.3	33%	0%	0%	96%	67%	0%	13%	0.0	5.7	2.2	0.0	2.3
11/04/2023	24.2	22.1	10.7	16.2	17.8	8.9	20.2	92%	0%	0%	67%	4%	0%	83%	0.0	2.5	0.4	0.0	5.0
12/04/2023	34.8	17.8	11.1	24.5	19.6	12.1	24.6	33%	0%	0%	79%	50%	4%	25%	0.0	7.9	1.5	0.0	4.0
13/04/2023	20.7	11.3	8.1	13.7	12.6	8.5	11.9	33%	38%	8%	33%	8%	21%	29%	0.0	0.7	0.2	0.0	1.4
14/04/2023	23.3	18.6	8.6	13.0	13.1	12.2	22.3	0%	29%	29%	4%	4%	75%	0%	0.0	0.0	0.0	0.5	0.0
15/04/2023	26.6	24.3	13.2	12.9	13.6	20.4	19.3	58%	8%	4%	46%	4%	25%	58%	0.0	1.9	0.0	6.2	5.1
16/04/2023	44.8	16.1	15.6	27.0	27.8	17.1	26.0	25%	8%	0%	63%	63%	0%	25%	0.0	5.1	6.1	0.0	0.7



			24-hour a	verage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (୨	%)		HVO So	outh's estim	ated max. c (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
17/04/2023	25.8	29.8	20.0	18.5	17.8	21.7	28.4	38%	0%	42%	4%	0%	67%	38%	1.8	0.3	0.0	4.5	2.3
18/04/2023	24.5	35.0	26.2	16.1	14.6	32.5	36.3	0%	0%	71%	4%	4%	79%	4%	2.4	0.0	0.0	5.4	0.0
19/04/2023	27.5	30.9	25.5	21.4	22.0	27.4	31.7	42%	4%	33%	13%	0%	50%	42%	1.7	0.1	0.0	3.1	3.6
20/04/2023	17.9	17.4	16.4	12.7	12.2	17.3	21.9	0%	21%	25%	0%	0%	83%	0%	0.0	0.0	0.0	1.9	0.0
21/04/2023	20.8	22.3	12.9	13.2	15.3	16.7	26.9	0%	4%	63%	0%	0%	88%	0%	0.1	0.0	0.0	0.9	0.0
22/04/2023	18.3	27.5	10.7	12.5	12.8	15.9	27.8	0%	0%	38%	0%	0%	88%	0%	0.2	0.0	0.0	1.3	0.0
23/04/2023	13.4	20.1	11.1	8.2	9.4	16.9	17.1	13%	0%	58%	0%	0%	88%	21%	1.8	0.0	0.0	5.1	1.1
24/04/2023	14.8	22.8	14.4	9.7	11.3	16.9	23.8	0%	0%	92%	0%	0%	100%	0%	1.8	0.0	0.0	3.0	0.0
25/04/2023	22.5	29.1	18.9	19.6	21.4	23.4	23.9	0%	0%	50%	0%	0%	88%	0%	1.6	0.0	0.0	3.8	0.0
26/04/2023	20.1	24.1	15.3	11.7	-	21.2	17.7	17%	13%	33%	4%	0%	67%	17%	2.0	0.2	-	3.5	1.8
27/04/2023	26.4	39.5	15.6	15.2	10.5	23.1	21.7	4%	0%	46%	4%	4%	79%	8%	1.3	0.0	0.0	6.8	0.1
28/04/2023	36.8	24.3	22.7	18.3	14.3	29.3	25.6	46%	8%	4%	46%	17%	4%	46%	0.0	1.4	0.0	0.0	1.1
29/04/2023	41.0	20.4	17.8	22.7	26.2	18.1	33.2	58%	0%	4%	58%	25%	8%	42%	0.0	0.3	0.4	0.0	4.3
30/04/2023	7.1	7.9	4.2	7.5	9.9	4.4	14.1	38%	0%	0%	100%	63%	0%	13%	0.0	2.0	1.9	0.0	0.6
1/05/2023	10.9	9.2	7.3	9.9	10.9	5.7	24.2	33%	0%	0%	100%	67%	0%	4%	0.0	0.7	1.0	0.0	0.4
2/05/2023	16.5	12.2	10.3	14.2	13.5	8.2	38.6	21%	0%	0%	100%	79%	0%	0%	0.0	0.7	1.1	0.0	0.0
3/05/2023	27.4	14.0	11.7	22.4	19.6	11.0	46.2	21%	0%	0%	100%	79%	0%	8%	0.0	3.9	2.5	0.0	0.1
4/05/2023	33.1	29.0	15.2	19.0	20.5	17.9	19.2	50%	8%	4%	42%	13%	17%	46%	0.0	2.2	0.6	2.8	3.4
5/05/2023	42.5	37.7	13.2	-	28.0	15.9	24.8	67%	17%	4%	42%	4%	8%	67%	0.0	-	0.4	0.0	4.0
6/05/2023	43.4	28.8	18.8	-	21.9	15.2	28.0	71%	0%	0%	75%	25%	0%	67%	0.0	-	1.4	0.0	6.1
7/05/2023	20.8	20.3	9.7	-	18.8	7.6	22.2	38%	0%	0%	96%	63%	0%	33%	0.0	-	2.7	0.0	1.3
8/05/2023	19.8	17.7	8.7	-	22.7	6.7	24.2	29%	0%	0%	96%	71%	0%	25%	0.0	-	4.2	0.0	2.5
9/05/2023	-	25.3	12.7	-	22.6	15.8	29.8	67%	4%	25%	50%	0%	33%	63%	0.0	-	0.0	0.8	8.9
10/05/2023	26.4	34.7	16.9	-	22.2	19.7	28.5	42%	13%	21%	4%	0%	42%	42%	0.2	-	0.0	1.6	5.2
11/05/2023	30.7	30.0	19.0	-	20.0	21.1	22.3	33%	0%	33%	0%	4%	63%	33%	1.9	-	0.0	1.1	3.8
12/05/2023	33.4	27.1	17.3	-	17.2	20.4	19.4	58%	8%	13%	25%	0%	38%	58%	0.0	-	0.0	3.8	4.5
13/05/2023	32.9	36.5	22.9	-	17.7	28.5	25.5	38%	8%	54%	4%	0%	67%	38%	3.9	-	0.0	5.4	2.5



		-	24-hour a	iverage lev	∕el (µg/m³)	_		Pe	ercentage	of time do	wnwind (%	%)		HVO S	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
14/05/2023	19.1	22.2	15.0	-	10.7	25.1	27.2	25%	0%	58%	0%	0%	63%	29%	2.1	-	0.0	2.3	2.9
15/05/2023	21.2	22.6	17.4	-	12.7	15.8	20.0	21%	17%	21%	13%	4%	38%	29%	2.3	-	0.0	0.8	2.4
16/05/2023	57.7	31.3	13.2	14.3	16.7	16.9	23.6	46%	0%	38%	29%	13%	38%	50%	0.4	1.0	0.0	1.0	5.5
17/05/2023	37.9	25.9	12.3	15.7	18.8	11.1	17.3	0%	38%	17%	4%	8%	71%	0%	0.0	0.0	0.1	0.0	0.0
18/05/2023	18.8	17.7	12.0	13.5	15.6	7.5	16.2	58%	0%	13%	4%	8%	21%	58%	0.0	0.0	0.4	0.1	4.2
19/05/2023	16.3	24.6	7.4	15.3	15.9	5.8	13.8	96%	0%	0%	58%	4%	0%	83%	0.0	5.3	0.1	0.0	3.5
20/05/2023	14.6	21.5	11.0	18.2	22.0	9.2	44.0	33%	0%	0%	100%	67%	0%	29%	0.0	2.3	1.7	0.0	2.0
21/05/2023	17.2	15.3	12.8	23.5	31.8	8.2	37.5	21%	0%	0%	92%	79%	0%	21%	0.0	7.8	10.6	0.0	3.3
22/05/2023	26.5	21.9	10.0	19.1	23.5	7.6	-	71%	0%	0%	75%	25%	0%	67%	0.0	5.0	2.5	0.0	-
23/05/2023	33.8	46.9	21.3	24.6	27.7	20.8	-	63%	8%	13%	54%	0%	29%	63%	1.2	3.7	0.0	3.4	-
24/05/2023	45.0	37.7	18.6	30.2	32.8	14.7	36.6	83%	0%	0%	71%	13%	0%	71%	0.0	4.3	0.0	0.0	6.4
25/05/2023	35.8	30.9	28.9	59.4	50.0	26.8	54.8	63%	0%	0%	96%	38%	0%	38%	0.0	25.4	2.3	0.0	8.9
26/05/2023	27.5	21.7	18.4	29.4	32.3	15.8	38.3	33%	13%	0%	58%	29%	13%	21%	0.0	5.2	3.5	0.0	2.7
27/05/2023	20.2	21.5	6.9	17.0	16.4	8.7	21.9	63%	0%	0%	79%	38%	0%	63%	0.0	3.5	0.9	0.0	4.0
28/05/2023	12.5	18.2	7.6	20.5	24.5	6.7	30.2	54%	0%	0%	100%	46%	0%	42%	0.0	7.4	2.0	0.0	6.5
29/05/2023	19.0	18.8	10.6	26.9	22.3	7.3	36.1	42%	0%	0%	96%	58%	0%	25%	0.0	10.8	3.5	0.0	8.4
30/05/2023	19.6	21.3	15.3	16.1	20.3	9.3	42.3	46%	0%	0%	100%	54%	0%	29%	0.0	2.5	2.1	0.0	6.2
31/05/2023	23.2	19.3	13.5	27.3	29.6	9.6	50.8	25%	0%	0%	92%	71%	0%	17%	0.0	5.8	7.9	0.0	3.7
1/06/2023	24.2	25.9	13.4	30.6	36.5	8.7	33.6	42%	0%	0%	92%	58%	0%	33%	0.0	10.6	12.1	0.0	4.8
2/06/2023	59.2	48.1	27.9	24.4	28.1	23.7	28.3	33%	0%	46%	17%	4%	63%	33%	7.7	0.6	0.0	2.2	1.2
3/06/2023	42.2	26.4	18.5	16.3	21.5	19.2	41.5	58%	0%	21%	58%	4%	25%	46%	0.4	0.6	0.0	3.3	9.0
4/06/2023	16.1	28.6	25.2	14.3	17.0	22.9	36.6	0%	0%	100%	0%	0%	100%	0%	5.3	0.0	0.0	4.4	0.0
5/06/2023	13.5	27.6	21.6	13.4	13.5	21.7	26.3	0%	0%	75%	0%	0%	100%	0%	4.6	0.0	0.0	5.1	0.0
6/06/2023	16.6	30.8	25.8	12.2	9.6	22.5	13.5	8%	0%	42%	8%	0%	75%	8%	5.8	0.0	0.0	6.8	0.0
7/06/2023	30.3	34.1	17.1	12.5	11.3	21.7	16.6	42%	8%	33%	17%	0%	42%	42%	1.4	1.0	0.0	4.2	2.6
8/06/2023	17.0	16.1	7.4	11.0	12.5	8.1	19.9	71%	4%	0%	67%	21%	0%	71%	0.0	1.5	0.4	0.0	5.5
9/06/2023	13.3	13.2	8.0	16.7	18.7	7.8	21.5	29%	0%	0%	100%	71%	0%	21%	0.0	6.0	3.2	0.0	4.4



			24-hour a	iverage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (%	%)		HVO So	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
10/06/2023	46.8	19.9	9.3	18.0	16.2	10.6	22.5	67%	4%	4%	75%	25%	4%	54%	0.0	3.8	0.0	0.0	4.8
11/06/2023	53.1	36.9	12.5	22.1	23.0	16.9	27.0	58%	8%	17%	33%	0%	29%	58%	0.1	0.2	0.0	1.9	5.9
12/06/2023	56.4	35.5	11.5	20.0	16.5	17.5	33.4	63%	13%	0%	58%	13%	4%	58%	0.0	1.7	0.0	0.0	9.7
13/06/2023	33.4	21.3	7.1	14.3	15.9	9.3	25.6	79%	0%	0%	71%	21%	0%	63%	0.0	3.9	2.4	0.0	9.7
14/06/2023	12.8	10.8	7.4	14.4	9.5	5.7	17.2	46%	0%	0%	100%	54%	0%	4%	0.0	4.6	1.3	0.0	0.6
15/06/2023	17.4	15.7	7.2	12.9	11.0	6.1	24.8	54%	0%	0%	100%	46%	0%	54%	0.0	2.8	0.0	0.0	8.5
16/06/2023	37.8	16.1	8.8	16.8	18.3	8.7	20.8	83%	0%	0%	71%	4%	0%	67%	0.0	4.4	0.1	0.0	7.4
17/06/2023	24.4	21.7	8.9	17.1	16.1	11.8	17.1	71%	0%	0%	100%	29%	0%	63%	0.0	3.5	0.2	0.0	1.7
18/06/2023	25.7	16.8	8.9	31.4	22.7	8.9	24.7	38%	0%	0%	100%	63%	0%	25%	0.0	16.9	5.1	0.0	3.2
19/06/2023	16.9	16.8	7.8	17.8	20.7	6.2	29.8	29%	0%	0%	100%	71%	0%	8%	0.0	4.3	6.5	0.0	0.5
20/06/2023	-	15.1	11.5	15.6	17.5	7.8	25.0	50%	4%	0%	58%	33%	0%	46%	0.0	2.0	0.6	0.0	3.2
21/06/2023	-	46.8	23.2	28.1	29.0	27.8	24.4	46%	4%	38%	13%	0%	54%	46%	4.7	1.0	0.0	6.5	3.8
22/06/2023	-	38.7	28.0	18.5	36.1	32.6	40.8	58%	4%	13%	46%	13%	29%	63%	0.1	1.7	1.3	1.7	12.0
23/06/2023	-	12.1	7.3	3.1	13.1	6.7	23.5	33%	0%	0%	96%	63%	0%	21%	0.0	0.0	1.9	0.0	1.7
24/06/2023	-	10.7	4.7	13.9	13.0	5.0	29.8	54%	0%	0%	92%	46%	0%	21%	0.0	4.0	0.5	0.0	5.2
25/06/2023	-	16.2	6.4	16.8	12.6	6.2	37.6	33%	0%	0%	96%	67%	0%	21%	0.0	3.5	2.2	0.0	5.6
26/06/2023	-	19.0	8.8	20.0	18.4	7.2	50.7	8%	0%	0%	100%	92%	0%	4%	0.0	3.6	2.2	0.0	2.3
27/06/2023	-	16.9	10.3	20.0	15.1	8.5	44.2	38%	0%	0%	100%	63%	0%	25%	0.0	3.8	2.3	0.0	8.6
28/06/2023	-	12.9	9.3	16.4	18.6	6.6	26.0	42%	0%	0%	96%	54%	0%	13%	0.0	4.0	3.4	0.0	1.6
29/06/2023	-	1.5	6.3	15.5	11.5	3.0	31.6	38%	0%	0%	100%	63%	0%	29%	0.0	6.5	1.1	0.0	5.2
30/06/2023	8.0	8.1	9.6	18.5	23.0	6.0	40.9	71%	0%	0%	100%	29%	0%	0%	0.0	5.1	1.1	0.0	0.0
1/07/2023	13.0	11.5	7.0	19.3	23.4	5.4	34.8	83%	0%	0%	83%	17%	0%	33%	0.0	4.4	1.8	0.0	8.5
2/07/2023	31.7	30.4	14.5	20.0	20.8	15.9	23.9	46%	0%	33%	8%	0%	42%	46%	1.6	1.6	0.0	2.0	5.1
3/07/2023	43.5	34.2	24.4	31.0	23.9	8.0	36.7	33%	0%	46%	8%	4%	58%	38%	4.7	3.9	0.0	1.0	13.6
4/07/2023	13.4	12.8	12.0	10.0	11.8	3.2	19.1	13%	8%	13%	17%	8%	21%	4%	0.1	0.1	0.0	0.0	0.0
5/07/2023	8.4	8.2	4.9	7.1	10.2	4.3	15.3	8%	0%	0%	100%	92%	0%	0%	0.0	0.6	3.0	0.0	0.0
6/07/2023	9.4	9.3	3.5	7.7	11.7	2.8	18.7	29%	0%	0%	100%	71%	0%	4%	0.0	1.1	1.8	0.0	0.5



		-	24-hour a	iverage lev	/el (µg/m³)	-		Pe	ercentage	of time do	wnwind (%	%)		HVO S	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
7/07/2023	11.8	10.9	6.0	10.9	11.6	4.4	24.3	13%	0%	0%	100%	88%	0%	0%	0.0	1.5	1.4	0.0	0.0
8/07/2023	16.6	20.9	8.4	17.3	14.1	8.8	34.0	4%	0%	0%	100%	96%	0%	0%	0.0	2.5	2.4	0.0	0.0
9/07/2023	20.2	19.4	13.6	26.4	21.3	11.1	31.2	21%	0%	0%	100%	79%	0%	8%	0.0	8.7	3.0	0.0	1.9
10/07/2023	15.2	14.8	8.7	20.9	17.6	6.7	32.0	38%	0%	0%	100%	63%	0%	13%	0.0	7.0	2.6	0.0	3.4
11/07/2023	28.7	16.3	11.5	15.1	14.4	12.1	16.9	63%	0%	0%	71%	25%	0%	54%	0.0	3.2	0.8	0.0	3.4
12/07/2023	56.2	47.2	12.9	21.8	20.2	20.4	27.8	58%	21%	21%	25%	4%	38%	58%	0.1	1.5	0.1	1.2	7.2
13/07/2023	28.9	24.2	10.7	25.6	19.8	11.1	28.3	79%	0%	0%	83%	21%	0%	63%	0.0	7.1	0.5	0.0	6.9
14/07/2023	25.8	19.0	13.4	31.2	21.1	15.4	36.8	58%	0%	0%	92%	42%	0%	50%	0.0	11.2	0.0	0.0	6.8
15/07/2023	28.4	17.7	10.2	32.0	27.6	11.9	41.6	58%	0%	0%	100%	42%	0%	42%	0.0	14.8	2.2	0.0	11.3
16/07/2023	69.8	39.6	14.7	27.5	26.1	15.5	44.0	25%	4%	25%	25%	8%	63%	25%	0.0	1.8	0.0	0.0	1.3
17/07/2023	18.3	33.7	23.3	17.6	14.0	23.7	20.1	0%	0%	42%	0%	0%	79%	0%	4.1	0.0	0.0	6.3	0.0
18/07/2023	25.1	15.9	9.1	24.0	19.9	9.1	26.1	54%	0%	0%	88%	38%	0%	50%	0.0	11.4	2.7	0.0	6.3
19/07/2023	35.8	32.8	12.1	13.6	14.5	16.6	16.4	46%	4%	17%	29%	0%	33%	46%	0.0	0.2	0.0	1.4	4.0
20/07/2023	38.5	41.7	13.3	34.7	32.5	14.7	49.3	58%	0%	0%	88%	42%	0%	50%	0.0	8.0	0.7	0.0	7.3
21/07/2023	21.1	17.5	9.0	17.8	16.7	7.4	34.9	46%	0%	0%	79%	42%	0%	38%	0.0	5.0	0.9	0.0	12.5
22/07/2023	38.9	36.4	8.4	16.9	17.0	14.4	22.7	54%	0%	17%	0%	0%	25%	54%	0.0	0.0	0.0	0.6	6.7
23/07/2023	35.1	36.0	17.7	19.8	20.6	21.7	33.6	46%	4%	33%	13%	0%	46%	46%	0.4	0.5	0.0	1.1	6.3
24/07/2023	26.0	23.9	14.1	10.6	10.1	18.2	29.7	0%	8%	25%	4%	4%	54%	0%	0.0	0.0	0.0	1.8	0.0
25/07/2023	27.7	-	15.3	13.4	14.0	13.8	19.5	46%	4%	21%	4%	0%	46%	46%	1.6	0.0	0.0	1.5	5.8
26/07/2023	40.7	-	13.8	16.9	17.0	16.3	27.1	67%	13%	0%	50%	13%	4%	58%	0.0	1.4	0.1	0.0	8.9
27/07/2023	58.1	35.2	11.6	21.8	24.4	14.8	27.0	75%	0%	0%	54%	8%	0%	79%	0.0	2.2	0.8	0.0	9.3
28/07/2023	47.3	22.3	14.0	37.4	23.4	14.4	46.7	46%	0%	0%	88%	54%	0%	42%	0.0	13.5	1.6	0.0	10.9
29/07/2023	36.8	23.4	17.1	37.0	27.7	18.9	55.7	75%	0%	0%	100%	25%	0%	63%	0.0	15.3	0.6	0.0	23.9
30/07/2023	26.3	39.1	12.7	31.1	25.5	11.7	43.0	38%	0%	0%	92%	63%	0%	25%	0.0	6.0	2.6	0.0	0.5
31/07/2023	18.7	22.9	11.3	16.7	16.4	5.5	32.9	71%	0%	0%	100%	29%	0%	50%	0.0	3.9	0.0	0.0	9.6
1/08/2023	19.1	39.4	21.5	23.4	25.6	18.3	27.5	50%	0%	17%	54%	8%	38%	29%	1.7	3.7	0.3	3.7	4.2
2/08/2023	19.4	39.2	30.7	24.1	23.7	30.7	33.6	0%	0%	71%	0%	0%	100%	0%	6.0	0.0	0.0	6.6	0.0



			24-hour a	iverage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (%	%)		HVO S	outh's estim	ated max. c (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
3/08/2023	31.6	35.5	13.3	12.8	-	15.7	22.5	63%	8%	0%	33%	4%	4%	63%	0.0	1.5	-	0.5	4.0
4/08/2023	56.7	37.4	17.5	28.9	24.0	20.5	36.4	63%	0%	4%	75%	25%	4%	63%	0.2	3.5	0.3	0.2	7.7
5/08/2023	58.9	37.0	14.4	45.1	38.6	17.9	40.9	54%	13%	0%	50%	17%	4%	38%	0.0	5.3	1.0	0.6	3.0
6/08/2023	22.5	37.6	21.4	15.3	16.1	18.1	23.1	0%	8%	63%	0%	0%	100%	0%	2.5	0.0	0.0	2.7	0.0
7/08/2023	20.5	37.2	24.2	14.3	12.4	23.9	17.8	4%	0%	58%	13%	17%	63%	4%	6.6	0.0	0.0	6.3	0.0
8/08/2023	21.3	29.0	24.4	12.8	10.3	25.5	17.5	8%	17%	50%	4%	0%	63%	8%	7.9	0.0	0.0	6.7	0.0
9/08/2023	47.8	24.4	17.3	23.4	22.1	19.0	28.9	63%	0%	0%	46%	17%	0%	58%	0.0	3.1	0.8	0.0	8.8
10/08/2023	59.6	30.7	15.2	49.7	40.3	14.1	47.1	33%	0%	0%	75%	67%	0%	33%	0.0	17.4	8.5	0.0	4.9
11/08/2023	52.4	26.2	19.8	29.0	27.0	12.4	25.2	67%	4%	0%	25%	13%	4%	67%	0.0	3.4	0.5	0.0	7.5
12/08/2023	27.2	28.9	17.4	38.6	32.8	16.8	39.9	33%	4%	4%	71%	46%	8%	21%	0.0	12.4	3.5	0.6	1.7
13/08/2023	33.8	31.5	17.3	23.6	20.2	19.2	30.2	33%	4%	13%	33%	13%	25%	29%	0.4	4.8	0.0	1.1	10.2
14/08/2023	12.1	14.4	10.2	12.0	11.4	11.9	12.1	25%	8%	0%	67%	46%	8%	25%	0.0	2.5	1.0	1.3	0.6
15/08/2023	11.6	16.6	7.8	8.8	7.0	7.9	8.9	0%	0%	33%	4%	4%	50%	0%	1.3	0.4	0.0	1.2	0.0
16/08/2023	16.4	21.7	14.4	9.3	9.0	14.9	14.6	25%	0%	13%	4%	4%	46%	29%	0.4	0.0	0.0	2.4	1.3
17/08/2023	26.1	17.3	10.0	22.1	13.3	8.4	25.4	63%	0%	0%	75%	33%	0%	63%	0.0	9.0	0.4	0.0	6.9
18/08/2023	9.5	7.9	6.1	10.4	7.6	5.6	17.7	8%	0%	0%	100%	88%	0%	8%	0.0	2.1	0.5	0.0	0.6
19/08/2023	12.5	11.8	7.7	13.6	14.4	6.2	39.0	4%	0%	0%	100%	96%	0%	0%	0.0	0.4	1.5	0.0	0.0
20/08/2023	20.9	15.8	6.7	16.8	15.5	9.9	21.9	42%	8%	0%	38%	17%	0%	50%	0.0	2.4	0.6	0.0	3.3
21/08/2023	28.4	23.2	9.0	16.8	13.6	5.4	23.7	54%	0%	0%	63%	33%	0%	50%	0.0	3.1	0.2	0.0	5.6
22/08/2023	-	26.6	16.1	30.6	24.6	15.3	30.2	75%	0%	0%	67%	4%	4%	75%	0.0	5.3	0.0	0.0	9.1
23/08/2023	-	21.3	18.8	22.2	19.3	13.4	31.6	33%	4%	17%	50%	21%	21%	29%	0.1	5.1	0.4	1.0	4.0
24/08/2023	26.3	36.6	26.8	19.6	13.3	30.1	22.9	0%	13%	54%	0%	0%	79%	0%	1.3	0.0	0.0	10.2	0.0
25/08/2023	-	32.4	25.2	29.3	25.0	20.6	29.3	46%	0%	13%	25%	0%	33%	46%	0.0	2.3	0.0	1.5	3.2
26/08/2023	18.8	34.0	27.0	19.4	16.6	29.8	28.0	29%	0%	50%	8%	0%	71%	29%	6.4	0.8	0.0	5.7	4.7
27/08/2023	14.8	35.7	17.2	17.7	13.7	21.8	22.3	29%	4%	33%	0%	0%	67%	29%	3.6	0.0	0.0	6.2	3.6
28/08/2023	-	32.9	26.1	21.6	14.8	24.7	22.6	25%	0%	33%	4%	0%	50%	29%	8.7	0.0	0.0	4.9	3.3
29/08/2023	-	35.8	18.6	29.9	27.1	31.4	31.5	58%	4%	0%	38%	4%	13%	58%	0.0	3.1	0.0	3.6	4.0



			24-hour a	iverage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (9	%)		HVO S	outh's estim	ated max. c (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
30/08/2023	-	33.5	26.6	40.8	36.2	18.6	47.4	46%	0%	0%	67%	33%	4%	50%	0.0	7.1	1.1	0.0	7.7
31/08/2023	12.9	18.3	10.9	13.7	10.2	11.9	14.7	58%	13%	8%	50%	4%	33%	33%	0.0	1.4	0.0	1.2	2.9
1/09/2023	15.3	23.1	15.8	14.8	13.0	17.9	21.7	38%	0%	42%	38%	4%	50%	38%	1.7	2.0	0.0	4.8	2.8
2/09/2023	29.5	37.5	20.7	16.8	13.9	22.9	25.6	21%	0%	38%	0%	8%	71%	21%	2.9	0.0	0.0	4.9	1.0
3/09/2023	28.6	33.1	20.4	13.3	-	20.3	29.5	25%	0%	33%	8%	4%	58%	25%	3.3	0.0	-	1.4	6.7
4/09/2023	26.6	36.2	27.5	18.9	-	32.9	33.4	8%	17%	33%	4%	4%	50%	8%	3.7	0.0	-	4.8	0.6
5/09/2023	26.4	22.7	14.5	34.8	18.4	8.9	34.1	25%	0%	0%	71%	67%	0%	29%	0.0	16.2	2.5	0.0	0.0
6/09/2023	35.3	41.4	27.3	32.4	30.8	27.1	-	54%	0%	17%	42%	4%	38%	50%	1.6	3.5	0.1	6.0	-
7/09/2023	42.6	36.3	46.0	41.3	34.3	29.6	53.5	71%	0%	4%	38%	13%	8%	71%	0.0	5.7	0.0	1.7	15.3
8/09/2023	12.7	9.5	7.2	15.8	10.6	5.7	17.3	29%	0%	0%	96%	71%	0%	21%	0.0	8.9	1.8	0.0	4.4
9/09/2023	15.9	17.8	9.0	15.2	12.6	9.1	20.8	38%	4%	0%	75%	38%	8%	21%	0.0	3.0	0.3	0.8	2.2
10/09/2023	25.2	36.1	17.1	30.0	18.2	16.8	21.9	38%	8%	17%	4%	4%	42%	38%	1.4	0.3	0.1	1.7	4.2
11/09/2023	36.1	32.7	23.7	28.7	18.4	31.4	31.0	21%	8%	42%	4%	0%	67%	21%	3.5	0.2	0.0	4.3	6.7
12/09/2023	35.4	37.8	29.2	36.2	29.2	27.3	30.6	46%	0%	13%	8%	0%	33%	50%	2.8	1.6	0.0	1.9	3.7
13/09/2023	40.2	40.4	31.7	37.5	31.1	32.4	38.1	42%	0%	25%	21%	0%	33%	42%	1.3	4.8	0.0	2.7	6.8
14/09/2023	45.4	42.4	49.1	30.0	22.6	38.8	37.0	42%	4%	21%	29%	0%	46%	42%	5.1	0.7	0.0	4.6	5.6
15/09/2023	77.1	43.5	28.6	36.0	31.4	21.2	37.7	54%	0%	0%	71%	29%	0%	54%	0.0	4.6	1.4	0.0	4.8
16/09/2023	49.1	36.1	18.3	49.3	31.1	21.2	59.2	71%	0%	4%	96%	29%	8%	63%	0.1	21.6	0.3	0.1	23.0
17/09/2023	59.5	43.4	25.5	53.0	32.3	27.4	51.9	38%	4%	4%	71%	46%	4%	38%	0.0	20.1	1.6	0.4	7.3
18/09/2023	108.9	46.1	39.5	52.5	48.0	33.3	50.6	63%	0%	0%	75%	29%	0%	58%	0.0	8.8	1.4	0.0	9.9
19/09/2023	71.1	56.2	35.0	53.9	38.1	28.3	93.6	79%	4%	0%	75%	21%	0%	67%	0.0	12.7	0.0	0.0	34.6
20/09/2023	49.2	41.5	32.5	73.9	54.2	32.0	93.5	75%	0%	0%	71%	21%	0%	75%	0.0	26.1	2.8	0.0	38.5
21/09/2023	59.0	37.6	28.0	52.6	32.3	30.4	48.3	13%	4%	38%	13%	4%	46%	13%	2.1	6.4	0.0	2.9	5.4
22/09/2023	30.1	36.9	28.1	28.3	15.9	20.4	42.1	0%	0%	88%	0%	0%	100%	0%	3.6	0.0	0.0	1.2	0.0
23/09/2023	35.1	33.5	35.7	24.9	15.1	30.1	35.4	21%	4%	79%	4%	0%	83%	17%	10.4	0.0	0.0	5.7	3.1
24/09/2023	23.6	33.1	33.3	33.5	14.6	29.3	30.0	0%	0%	58%	0%	0%	83%	0%	12.0	0.0	0.0	5.3	0.0
25/09/2023	54.4	29.5	35.0	33.9	20.5	22.3	37.7	54%	4%	8%	54%	21%	8%	54%	0.0	6.2	0.2	0.4	8.2



			24-hour a	iverage lev	vel (µg/m³)			Pe	ercentage	of time do	wnwind (୨	%)		HVO So	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
26/09/2023	54.5	44.6	44.6	50.7	34.6	28.6	44.4	42%	4%	25%	33%	4%	38%	42%	7.0	9.8	0.0	3.3	7.3
27/09/2023	28.2	31.6	23.6	36.7	25.9	27.4	43.8	25%	4%	33%	21%	8%	42%	29%	4.2	3.7	0.2	2.0	4.0
28/09/2023	19.4	25.2	19.1	16.5	11.4	15.1	20.3	4%	0%	63%	4%	0%	92%	0%	3.6	0.0	0.0	1.0	0.0
29/09/2023	29.5	31.6	19.6	25.0	16.8	17.0	29.3	50%	0%	17%	67%	21%	25%	42%	0.8	6.1	0.5	1.7	1.3
30/09/2023	55.5	30.5	28.5	30.4	21.9	34.1	35.5	46%	13%	13%	25%	8%	21%	46%	0.1	2.9	1.0	3.6	7.7
1/10/2023	61.4	42.9	33.0	64.6	48.6	28.5	74.7	75%	0%	4%	58%	17%	4%	63%	0.0	17.6	2.4	0.0	13.7
2/10/2023	49.5	65.4	63.6	-	44.7	52.0	63.5	4%	0%	71%	0%	0%	88%	4%	14.8	-	0.0	4.3	0.3
3/10/2023	46.6	41.0	26.4	-	33.8	26.0	63.3	63%	0%	0%	79%	33%	0%	38%	0.0	-	3.4	0.0	15.2
4/10/2023	37.6	21.6	25.7	-	30.8	27.3	55.8	58%	0%	0%	79%	42%	0%	46%	0.0	-	3.4	0.0	20.5
5/10/2023	11.8	8.3	7.4	-	11.1	2.7	17.5	8%	0%	0%	100%	92%	0%	8%	0.0	-	2.5	0.0	0.5
6/10/2023	18.0	24.0	18.3	17.7	17.5	13.7	22.9	46%	0%	50%	38%	0%	50%	42%	3.5	2.9	0.0	1.3	6.2
7/10/2023	22.7	22.5	18.1	22.8	13.8	20.2	21.9	0%	0%	67%	0%	0%	100%	0%	1.8	0.0	0.0	3.2	0.0
8/10/2023	16.5	35.5	21.5	23.4	11.4	19.9	20.6	4%	0%	63%	0%	0%	88%	4%	3.7	0.0	0.0	2.2	0.7
9/10/2023	-	27.2	20.4	18.5	-	20.0	27.4	58%	4%	13%	67%	13%	25%	50%	0.3	2.3	-	3.6	5.4
10/10/2023	37.0	36.3	35.1	27.3	-	32.3	38.0	13%	0%	50%	8%	4%	67%	17%	4.3	0.0	-	1.4	1.2
11/10/2023	31.3	35.8	38.9	24.5	23.9	31.3	42.6	13%	0%	42%	8%	4%	58%	17%	3.9	0.1	0.0	4.1	0.3
12/10/2023	47.9	36.3	33.8	39.5	37.1	24.3	45.6	63%	0%	0%	63%	33%	0%	58%	0.0	8.7	5.2	0.0	11.2
13/10/2023	30.9	16.9	19.4	24.3	16.6	9.9	20.6	29%	0%	4%	67%	42%	8%	8%	0.0	6.9	0.8	1.6	0.3
14/10/2023	30.0	25.5	16.3	36.9	26.1	8.7	46.4	38%	0%	0%	92%	63%	0%	33%	0.0	13.3	0.4	0.0	7.1
15/10/2023	49.2	28.2	20.1	50.1	39.5	21.7	38.9	25%	13%	0%	58%	46%	4%	25%	0.0	21.2	7.6	0.7	5.9
16/10/2023	71.7	32.8	34.9	54.4	35.0	23.2	54.8	29%	8%	0%	58%	46%	0%	25%	0.0	15.5	1.4	0.0	3.2
17/10/2023	46.1	37.8	27.9	27.6	25.5	16.6	40.5	0%	0%	38%	0%	0%	100%	0%	1.5	0.0	0.0	0.0	0.0
18/10/2023	-	27.1	30.0	26.5	11.9	22.8	27.2	0%	0%	75%	0%	0%	88%	0%	6.5	0.0	0.0	2.9	0.0
19/10/2023	4.9	34.1	40.9	25.5	18.4	24.3	33.4	0%	0%	67%	0%	0%	100%	0%	17.6	0.0	0.0	6.4	0.0
20/10/2023	37.6	35.8	45.7	32.9	30.5	37.1	49.7	33%	0%	13%	8%	0%	29%	33%	2.0	0.0	0.0	2.0	4.6
21/10/2023	40.4	38.0	50.7	37.8	30.5	35.5	55.1	21%	0%	0%	25%	8%	25%	21%	0.0	1.2	0.2	1.9	3.2
22/10/2023	59.3	33.2	26.7	50.3	40.5	27.1	69.7	25%	0%	4%	75%	58%	4%	21%	0.1	14.8	3.6	0.8	7.9



			24-hour a	iverage lev	vel (µg/m³	[;])			Pe	ercentage	of time do	wnwind (9	%)		HVO S	outh's estim	ated max. c (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
23/10/2023	34.3	43.6	43.9	45.9	32.6	26.5	55.1	29%	4%	4%	67%	50%	8%	25%	1.8	13.6	0.3	1.0	7.1
24/10/2023	64.0	52.4	37.2	48.3	47.7	28.9	52.1	79%	0%	0%	63%	21%	0%	71%	0.0	11.8	1.5	0.0	13.2
25/10/2023	60.2	51.2	49.6	81.9	57.0	37.0	64.9	21%	0%	29%	63%	42%	29%	17%	8.6	28.9	2.3	1.4	2.1
26/10/2023	5.7	21.5	18.0	16.3	17.0	13.2	28.0	0%	0%	63%	0%	0%	100%	0%	3.2	0.0	0.0	0.6	0.0
27/10/2023	9.8	11.8	8.3	6.6	9.1	8.2	18.7	0%	0%	58%	0%	0%	100%	0%	1.0	0.0	0.0	0.3	0.0
28/10/2023	15.8	19.3	12.0	8.6	10.4	11.9	20.3	0%	0%	58%	0%	0%	96%	0%	2.1	0.0	0.0	1.5	0.0
29/10/2023	28.5	16.6	15.8	22.3	21.1	23.6	21.6	33%	21%	8%	17%	4%	13%	54%	0.4	0.1	0.0	2.3	4.5
30/10/2023	55.5	29.6	21.6	40.9	34.5	26.7	54.9	88%	0%	0%	79%	13%	0%	71%	0.0	11.2	0.2	0.0	19.4
31/10/2023	50.8	49.1	34.5	45.2	45.5	28.2	73.8	25%	0%	25%	54%	38%	33%	25%	1.3	7.2	2.6	2.5	10.8
1/11/2023	22.0	35.9	39.7	21.7	22.8	27.0	35.6	0%	0%	92%	0%	0%	100%	0%	12.7	0.0	0.0	2.0	0.0
2/11/2023	20.8	28.9	37.8	19.9	16.7	22.1	35.5	0%	0%	75%	0%	0%	100%	0%	10.7	0.0	0.0	2.0	0.0
3/11/2023	21.4	32.2	34.0	17.1	14.8	18.0	40.7	0%	0%	75%	0%	0%	100%	0%	12.8	0.0	0.0	2.8	0.0
4/11/2023	22.7	36.8	22.8	19.1	15.5	21.6	38.3	0%	0%	83%	0%	0%	96%	0%	3.7	0.0	0.0	1.9	0.0
5/11/2023	11.1	26.6	20.1	10.4	9.4	14.1	24.1	0%	0%	100%	0%	0%	100%	0%	8.0	0.0	0.0	1.8	0.0
6/11/2023	15.4	27.0	22.6	11.2	13.6	18.6	33.2	0%	0%	79%	0%	0%	100%	0%	7.2	0.0	0.0	4.1	0.0
7/11/2023	19.7	30.7	27.7	12.5	11.4	21.9	28.0	17%	8%	42%	0%	0%	71%	21%	8.3	0.0	0.0	4.7	4.0
8/11/2023	33.0	22.6	29.2	25.1	24.2	23.0	32.0	38%	0%	8%	42%	25%	13%	38%	0.5	6.8	2.5	0.9	6.3
9/11/2023	30.0	17.9	33.8	20.1	27.1	26.7	29.6	25%	8%	0%	17%	8%	8%	21%	0.0	0.2	0.0	1.3	1.7
10/11/2023	26.2	22.4	18.7	18.1	14.8	18.7	23.0	33%	17%	21%	33%	8%	38%	29%	2.0	0.5	0.1	0.2	1.0
11/11/2023	30.9	21.4	22.1	22.4	20.1	21.6	32.4	50%	4%	8%	58%	25%	17%	50%	0.0	3.7	0.5	1.4	6.8
12/11/2023	39.7	40.3	25.1	59.5	41.3	25.8	57.8	21%	0%	4%	79%	54%	13%	0%	1.5	24.6	4.7	0.7	0.0
13/11/2023	25.7	37.2	43.7	37.4	25.8	30.8	39.0	0%	0%	75%	0%	0%	100%	0%	9.0	0.0	0.0	1.4	0.0
14/11/2023	38.7	40.8	40.3	41.2	31.3	30.9	52.0	17%	13%	17%	33%	25%	33%	21%	3.4	6.0	1.3	1.4	2.9
15/11/2023	36.1	35.2	44.5	43.2	31.4	27.0	36.1	25%	0%	38%	38%	21%	54%	21%	8.1	7.1	0.1	1.2	2.9
16/11/2023	30.3	33.7	36.5	27.6	-	22.5	31.9	21%	0%	50%	29%	13%	58%	21%	9.2	0.6	-	1.9	1.1
17/11/2023	21.9	21.7	16.5	16.3	12.9	14.5	22.9	0%	4%	42%	0%	0%	75%	0%	0.8	0.0	0.0	1.8	0.0
18/11/2023	15.6	25.1	20.8	15.9	10.9	17.2	34.5	0%	0%	79%	0%	0%	96%	0%	5.3	0.0	0.0	1.4	0.0



			24-hour a	verage lev	/el (µg/m³)			Pe	ercentage	of time do	wnwind (%	%)		HVO S	outh's estim	ated max. c (µg/m³)	ontribution t	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
19/11/2023	27.4	35.1	34.3	26.7	18.4	33.1	55.1	8%	0%	50%	4%	4%	54%	17%	6.6	0.0	0.0	3.5	3.3
20/11/2023	19.0	26.7	32.9	21.4	18.2	21.6	36.1	13%	4%	17%	13%	0%	63%	13%	1.8	0.5	0.0	1.5	2.1
21/11/2023	27.0	21.2	26.4	19.4	16.3	23.5	34.3	4%	0%	42%	0%	0%	42%	29%	2.2	0.0	0.0	2.5	1.4
22/11/2023	19.8	28.5	23.9	19.8	14.9	18.9	41.3	0%	0%	67%	0%	0%	88%	0%	3.3	0.0	0.0	1.4	0.0
23/11/2023	20.5	29.4	29.2	21.1	12.8	19.8	41.2	0%	0%	83%	0%	0%	100%	0%	9.3	0.0	0.0	4.5	0.0
24/11/2023	14.4	-	13.8	13.2	11.1	9.4	25.9	0%	0%	75%	0%	0%	100%	0%	3.0	0.0	0.0	1.1	0.0
25/11/2023	8.0	-	7.9	6.4	7.5	5.0	14.6	21%	0%	29%	21%	17%	54%	21%	0.3	1.1	0.6	0.0	1.5
26/11/2023	13.3	-	11.6	18.8	14.3	5.8	21.7	29%	0%	0%	96%	71%	0%	21%	0.0	7.9	1.3	0.0	2.8
27/11/2023	24.2	-	18.6	23.4	21.4	15.7	38.5	42%	0%	46%	29%	0%	50%	46%	3.1	3.8	0.0	1.1	7.9
28/11/2023	18.7	20.9	19.1	18.0	19.2	16.7	33.9	0%	4%	75%	0%	0%	100%	0%	1.4	0.0	0.0	0.1	0.0
29/11/2023	15.9	15.9	17.1	11.0	12.8	14.7	17.5	21%	8%	33%	21%	13%	50%	25%	0.5	0.2	0.1	1.8	0.9
30/11/2023	14.9	11.2	8.1	25.7	11.2	7.6	28.0	0%	0%	0%	100%	100%	0%	0%	0.0	14.1	1.3	0.0	0.0
1/12/2023	18.5	17.1	16.2	20.2	19.8	14.6	30.5	25%	0%	21%	75%	50%	21%	13%	3.0	5.9	0.4	2.1	2.1
2/12/2023	18.4	11.8	11.5	14.7	11.1	13.3	18.7	25%	4%	13%	50%	25%	17%	17%	0.6	2.0	0.1	1.0	1.4
3/12/2023	28.4	22.7	15.6	20.3	17.7	15.6	20.5	33%	8%	38%	38%	17%	42%	29%	2.7	2.8	0.3	2.1	2.3
4/12/2023	18.9	26.3	31.6	17.3	13.9	21.0	36.3	0%	0%	96%	0%	0%	100%	0%	14.4	0.0	0.0	4.1	0.0
5/12/2023	31.7	27.3	21.7	27.2	29.9	27.1	40.0	63%	0%	0%	58%	13%	8%	58%	0.0	4.9	1.2	0.5	8.3
6/12/2023	45.8	56.3	45.1	51.2	46.1	45.7	52.8	29%	0%	58%	33%	8%	58%	21%	13.2	9.0	0.0	6.8	4.5
7/12/2023	32.3	56.0	-	39.8	39.8	44.7	42.3	25%	0%	54%	21%	4%	58%	25%	-	0.1	0.1	3.9	1.3
8/12/2023	34.7	26.2	-	42.1	38.2	27.8	42.7	63%	0%	4%	54%	8%	4%	58%	-	8.6	0.1	0.0	5.4
9/12/2023	33.8	51.9	16.2	43.4	31.5	27.6	51.3	25%	4%	4%	71%	54%	13%	25%	0.0	11.3	2.3	1.0	1.4
10/12/2023	26.0	37.8	11.8	32.3	20.9	23.6	57.4	0%	0%	83%	0%	0%	100%	0%	0.0	0.0	0.0	1.3	0.0
11/12/2023	35.5	57.2	22.8	50.8	35.1	41.3	55.5	0%	0%	63%	0%	0%	75%	0%	0.0	0.0	0.0	3.2	0.0
12/12/2023	20.3	35.1	9.2	29.5	18.3	24.8	43.7	0%	0%	88%	0%	0%	100%	0%	0.0	0.0	0.0	0.7	0.0
13/12/2023	38.4	46.8	14.6	46.2	37.8	33.8	47.1	25%	8%	42%	8%	4%	46%	25%	0.0	0.0	0.0	2.7	2.7
14/12/2023	44.8	35.4	14.1	51.0	43.8	19.5	53.5	8%	0%	0%	79%	71%	0%	8%	0.0	13.4	13.5	0.0	2.4
15/12/2023	31.6	52.4	21.8	57.4	42.5	54.4	50.2	0%	0%	71%	0%	0%	88%	0%	1.7	0.0	0.0	11.8	0.0



			24-hour a	iverage lev	∕el (µg/m³)			Pe	ercentage	of time do	wnwind (%)		HVO S	outh's estim	ated max. co (µg/m³)	ontribution	to level
Date	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Golden Highway	Howick	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth	Jerrys Plains	Knodlers Lane	Maison Dieu	Wandewoi	Warkworth
16/12/2023	30.4	42.9	13.0	56.6	31.8	34.5	58.4	17%	0%	13%	67%	50%	21%	13%	0.0	22.5	2.0	2.4	0.8
17/12/2023	25.2	54.5	15.4	61.9	30.9	36.5	54.9	0%	0%	88%	0%	0%	100%	0%	0.0	0.0	0.0	1.5	0.0
18/12/2023	33.8	61.3	20.4	52.6	37.3	43.3	57.7	8%	0%	58%	0%	0%	79%	17%	0.2	0.0	0.0	2.5	0.3
19/12/2023	54.5	47.8	34.5	56.7	54.5	51.4	60.1	46%	0%	4%	46%	17%	4%	33%	0.0	5.4	1.2	1.2	6.4
20/12/2023	19.6	14.4	10.8	12.0	15.1	10.3	15.7	8%	4%	25%	13%	13%	54%	8%	0.5	0.1	0.5	0.3	1.0
21/12/2023	17.6	14.9	4.1	10.4	12.2	10.1	26.8	0%	4%	50%	0%	0%	96%	0%	0.0	0.0	0.0	0.0	0.0
22/12/2023	23.8	32.6	7.0	29.4	20.8	23.8	29.9	0%	0%	83%	0%	0%	100%	0%	0.0	0.0	0.0	4.0	0.0
23/12/2023	28.0	24.7	-	16.4	13.2	21.7	23.6	17%	4%	33%	13%	13%	42%	17%	-	0.0	0.0	3.8	2.2
24/12/2023	14.1	10.2	-	12.2	9.8	10.3	12.4	13%	8%	17%	13%	4%	50%	13%	-	0.4	0.2	2.8	0.8
25/12/2023	13.2	15.2	-	17.2	14.1	12.9	14.5	0%	4%	58%	0%	0%	83%	0%	-	0.0	0.0	0.9	0.0
26/12/2023	18.0	16.4	-	20.9	15.0	18.4	18.5	38%	4%	4%	17%	8%	17%	33%	-	0.8	0.0	0.2	3.3
27/12/2023	20.2	20.6	6.8	24.6	14.8	13.7	24.4	25%	4%	4%	63%	42%	21%	29%	0.0	9.5	0.6	0.1	1.9
28/12/2023	17.0	20.0	7.1	21.8	15.2	13.3	21.0	38%	0%	8%	75%	38%	17%	29%	0.0	9.9	0.3	0.7	2.6
29/12/2023	24.5	22.6	7.7	28.9	20.0	13.3	31.8	42%	0%	13%	63%	33%	13%	29%	0.0	10.4	1.9	0.9	2.9
30/12/2023	21.6	34.7	7.6	27.5	14.4	19.1	27.9	8%	8%	46%	33%	29%	46%	8%	0.0	4.4	0.1	3.1	0.8
31/12/2023	16.0	31.0	7.4	38.7	18.0	19.4	25.0	0%	0%	92%	0%	0%	92%	0%	0.0	0.0	0.0	0.6	0.0

- No data

Note for this annual review, TEOM data time was assessed per Australian Eastern Standard Time (AEST) as used by DCCEEW, however some minor differences arise with the operational data which uses Australian Eastern Daylight Time (AEDT). Some minor differences also arise as HVO collects data in real-time from DCCEEW monitors using a separate HVO logger which may result in minor additional time shift effect.

Table B-4: 24-hour average PM₁₀ HVAS levels, percent time downwind and estimated contributions – HVO North

Data	Descentage of time downwind $(\%)$	24 hour average DM., level (ug/m3)	HVO North's estimated max.
Date	Percentage of time downwind (%)	24-nour average Pivi10 level (µg/m²)	contribution to PM_{10} level (µg/m ³)

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Date		Percentage of tin	ne downwind (%)			24-hour a	average PM10 leve	el (μg/m³)		HVO North's e contribution to P	stimated max. M10 level (μg/m³)
	Cheshunt East	Gliding Club	Long Point	Kilburnie South	Estimated Background	Cheshunt East	Gliding Club	Long Point	Kilburnie South	Cheshunt East	Kilburnie South
5/01/2023	0%	0%	0%	0%	13.9	9.8	14.9	8.2	12.1	0.0	0.0
11/01/2023	0%	0%	0%	0%	21.0	15.3	21.8	14.2	22.5	0.0	0.0
17/01/2023	0%	0%	0%	0%	13.8	10.2	14.9	11.5	23.2	0.0	0.0
23/01/2023	0%	0%	0%	4%	17.8	15.5	16.5	13.1	17.8	0.0	0.0
29/01/2023	33%	8%	13%	13%	18.1	22.5	30.3	20.8	35.2	4.4	12.2
4/02/2023	100%	4%	29%	0%	24.0	-	26.6	32.9	56.6	-	0.0
10/02/2023	33%	25%	13%	4%	16.2	21.0	25.4	18.2	18.3	4.8	9.2
16/02/2023	13%	8%	8%	13%	29.6	16.5	37.3	29.6	32.2	0.0	7.7
22/02/2023	0%	0%	0%	0%	8.2	6.9	8.6	7.1	5.2	0.0	0.0
28/02/2023	0%	0%	0%	0%	19.3	13.0	16.7	12.6	20.2	0.0	0.0
6/03/2023	92%	8%	67%	0%	27.3	61.1	63.4	39.8	23.1	20.3	36.1
12/03/2023	29%	0%	4%	0%	29.2	25.4	24.2	23.4	24.0	0.0	0.0
18/03/2023	29%	13%	13%	17%	26.3	35.3	44.7	28.3	40.1	9.0	18.4
24/03/2023	21%	0%	21%	0%	21.8	15.1	20.0	12.5	16.3	0.0	0.0
30/03/2023	92%	0%	29%	0%	6.6	-	14.7	11.5	7.4	-	0.0
5/04/2023	13%	29%	8%	4%	14.2	15.3	23.7	14.2	17.1	1.1	9.5
11/04/2023	79%	29%	58%	0%	12.5	23.7	24.2	15.4	8.2	11.2	11.7
17/04/2023	8%	33%	4%	0%	17.0	18.0	26.6	15.9	16.4	1.1	9.7
23/04/2023	0%	17%	0%	4%	9.1	8.0	13.2	6.5	-	0.0	4.1
29/04/2023	71%	29%	29%	0%	18.9	24.3	40.3	24.6	19.4	5.4	21.4
5/05/2023	54%	25%	33%	4%	14.5	32.0	46.6	26.2	-	17.5	32.1
11/05/2023	8%	33%	0%	4%	15.3	17.3	24.7	15.3	17.0	2.0	9.4
17/05/2023	4%	0%	0%	0%	18.8	15.1	15.8	17.2	9.5	0.0	0.0
23/05/2023	58%	4%	58%	0%	19.9	33.5	33.0	26.4	18.4	13.7	0.0
29/05/2023	100%	4%	29%	0%	10.2	38.2	23.1	27.5	4.0	28.0	0.0
4/06/2023	0%	0%	0%	0%	18.0	12.0	19.7	11.8	22.4	0.0	0.0
10/06/2023	88%	4%	54%	0%	11.9	19.8	31.4	17.7	7.7	7.9	0.0

Date		Percentage of tin	ne downwind (%)			24-hour a	average PM ₁₀ leve	el (µg/m³)		HVO North's e contribution to P	stimated max. M10 level (μg/m³)
16/06/2023	75%	8%	71%	0%	9.2	21.9	30.0	17.4	3.4	12.7	20.8
22/06/2023	50%	25%	25%	4%	18.5	33.0	50.5	28.9	36.9	14.5	32.0
28/06/2023	92%	0%	33%	0%	12.0	17.7	15.3	13.1	5.4	5.7	0.0
4/07/2023	13%	4%	4%	17%	12.0	41.0	17.5	5.7	10.1	29.0	0.0
10/07/2023	100%	0%	42%	0%	8.6	121.0	13.0	16.9	4.4	112.4	0.0
16/07/2023	33%	8%	17%	0%	14.0	89.3	45.5	28.7	14.0	75.3	31.5
22/07/2023	38%	46%	0%	4%	16.4	54.7	28.1	19.6	13.2	38.3	11.7
28/07/2023	96%	13%	33%	0%	15.9	138.0	49.8	30.9	12.7	122.1	33.9
3/08/2023	42%	21%	33%	4%	14.6	27.1	31.6	20.3	15.9	12.5	17.0
9/08/2023	50%	29%	21%	4%	19.6	26.1	53.2	22.0	17.1	6.5	33.6
15/08/2023	8%	0%	4%	4%	8.0	6.6	4.1	3.9	9.8	0.0	0.0
21/08/2023	79%	29%	25%	0%	10.3	20.2	32.6	14.1	3.4	9.9	22.3
27/08/2023	13%	29%	0%	4%	10.4	11.4	29.6	9.3	14.1	1.1	19.3
2/09/2023	0%	21%	0%	0%	14.2	12.5	38.6	13.3	20.3	0.0	24.4
8/09/2023	100%	4%	21%	0%	6.6	8.7	7.2	10.5	4.1	2.1	0.0
14/09/2023	38%	13%	25%	8%	22.6	30.8	54.2	23.0	41.1	8.2	31.6
20/09/2023	79%	21%	54%	0%	36.5	86.4	124.0	73.7	40.0	44.9	87.5
26/09/2023	42%	4%	33%	0%	31.1	50.3	65.8	42.9	31.1	15.5	0.0
2/10/2023	4%	0%	0%	4%	48.8	44.8	81.0	41.6	51.6	0.0	0.0
8/10/2023	0%	4%	0%	4%	15.1	10.9	16.6	7.9	17.3	0.0	0.0
14/10/2023	92%	8%	25%	0%	14.4	37.2	24.6	47.2	7.0	22.8	10.2
20/10/2023	21%	25%	8%	13%	22.0	34.8	44.9	22.0	28.3	12.8	22.9
26/10/2023	0%	0%	0%	0%	15.0	12.3	18.2	10.8	13.9	0.0	0.0
1/11/2023	0%	0%	0%	0%	23.6	20.3	23.7	19.1	27.7	0.0	0.0
7/11/2023	13%	13%	0%	13%	9.3	10.6	23.6	7.2	15.9	1.3	14.3
13/11/2023	0%	0%	0%	0%	29.7	26.5	26.8	23.8	34.9	0.0	0.0
19/11/2023	4%	8%	0%	21%	21.7	19.6	41.6	16.2	30.6	0.0	19.9
25/11/2023	25%	17%	4%	0%	7.5	7.4	9.9	6.9	7.5	0.0	2.4
1/12/2023	79%	0%	25%	0%	19.4	22.3	18.6	17.2	8.3	2.9	0.0
7/12/2023	25%	8%	17%	17%	32.3	44.7	47.5	36.0	43.5	12.4	15.2
13/12/2023	13%	21%	4%	8%	34.2	39.0	49.6	34.2	37.5	4.8	15.4
19/12/2023	42%	13%	33%	13%	47.8	63.8	83.9	63.0	56.4	14.6	36.1

Date		Percentage of tin	ne downwind (%)			24-hour a	verage PM ₁₀ leve	el (µg/m³)		HVO North's e contribution to P	stimated max. M₁₀ level (µg/m³)
25/12/2023	0%	0%	0%	4%	13.9	10.8	12.3	13.4	8.9	0.0	0.0
31/12/2023	0%	0%	0%	0%	20.8	13.4	15.0	13.4	19.5	0.0	0.0

- No data

	I	Percentage of tir	ne downwind (%)		24-hour a	verage PM ₁₀ lev	el (μg/m³)		HVO South's e P	stimated max. co M ₁₀ level (μg/m³	ontribution to)
Date	Cheshunt East	Gliding Club	Long Point	Kilburnie South	Estimated Background	Cheshunt East	Gliding Club	Long Point	Kilburnie South	Gliding Club	Long Point	Kilburnie South
5/01/2023	0%	8%	0%	4%	13.9	9.8	14.9	8.2	12.1	0.0	1.0	0.0
11/01/2023	0%	71%	0%	42%	21.0	15.3	21.8	14.2	22.5	0.0	0.8	0.0
17/01/2023	0%	88%	0%	54%	13.8	10.2	14.9	11.5	23.2	0.0	1.1	0.0
23/01/2023	0%	54%	0%	29%	17.8	15.5	16.5	13.1	17.8	0.0	0.0	0.0
29/01/2023	0%	83%	17%	21%	18.1	22.5	30.3	20.8	35.2	0.0	12.2	2.7
4/02/2023	0%	100%	71%	0%	24.0		26.6	32.9	56.6	-	2.6	8.9
10/02/2023	0%	79%	8%	17%	16.2	21.0	25.4	18.2	18.3	0.0	9.2	2.0
16/02/2023	4%	83%	0%	33%	29.6	16.5	37.3	29.6	32.2	0.0	7.7	0.0
22/02/2023	0%	25%	0%	8%	8.2	6.9	8.6	7.1	5.2	0.0	0.4	0.0
28/02/2023	0%	79%	0%	29%	19.3	13.0	16.7	12.6	20.2	0.0	0.0	0.0
6/03/2023	0%	96%	33%	4%	27.3	61.1	63.4	39.8	23.1	0.0	36.1	12.5
12/03/2023	0%	75%	25%	33%	29.2	25.4	24.2	23.4	24.0	0.0	0.0	0.0
18/03/2023	0%	75%	8%	8%	26.3	35.3	44.7	28.3	40.1	0.0	18.4	2.0
24/03/2023	13%	67%	13%	38%	21.8	15.1	20.0	12.5	16.3	0.0	0.0	0.0
30/03/2023	0%	63%	38%	0%	6.6	-	14.7	11.5	7.4	-	8.1	4.9
5/04/2023	4%	67%	0%	33%	14.2	15.3	23.7	14.2	17.1	0.0	9.5	0.0
11/04/2023	0%	100%	17%	0%	12.5	23.7	24.2	15.4	8.2	0.0	11.7	2.9
17/04/2023	4%	71%	0%	33%	17.0	18.0	26.6	15.9	16.4	0.0	9.7	0.0
23/04/2023	0%	54%	0%	8%	9.1	8.0	13.2	6.5	-	0.0	4.1	0.0
29/04/2023	0%	92%	29%	4%	18.9	24.3	40.3	24.6	19.4	0.0	21.4	5.7

Table B-5: 24-hour average PM₁₀ HVAS levels, percent time downwind and estimated contributions – HVO South



Date	Percentage of time downwind (%)					24-hour a	verage PM ₁₀ leve	HVO South's estimated max. contribution to PM_{10} level ($\mu g/m^3$)				
5/05/2023	13%	79%	0%	4%	14.5	32.0	46.6	26.2	-	17.5	32.1	0.0
11/05/2023	13%	67%	0%	17%	15.3	17.3	24.7	15.3	17.0	2.0	9.4	0.0
17/05/2023	4%	25%	4%	13%	18.8	15.1	15.8	17.2	9.5	0.0	0.0	0.0
23/05/2023	4%	75%	0%	8%	19.9	33.5	33.0	26.4	18.4	0.0	13.2	0.0
29/05/2023	0%	96%	71%	0%	10.2	38.2	23.1	27.5	4.0	0.0	12.9	17.3
4/06/2023	0%	88%	0%	42%	18.0	12.0	19.7	11.8	22.4	0.0	1.7	0.0
10/06/2023	4%	83%	29%	4%	11.9	19.8	31.4	17.7	7.7	0.0	19.5	5.8
16/06/2023	8%	88%	8%	0%	9.2	21.9	30.0	17.4	3.4	12.7	20.8	8.2
22/06/2023	0%	83%	8%	13%	18.5	33.0	50.5	28.9	36.9	0.0	13.6	10.4
28/06/2023	4%	88%	75%	0%	12.0	17.7	15.3	13.1	5.4	0.0	3.3	1.1
4/07/2023	8%	75%	13%	17%	12.0	41.0	17.5	5.7	10.1	29.0	5.5	0.0
10/07/2023	0%	100%	83%	0%	8.6	121.0	13.0	16.9	4.4	0.0	4.4	8.3
16/07/2023	8%	71%	13%	4%	14.0	89.3	45.5	28.7	14.0	75.3	31.5	14.7
22/07/2023	13%	79%	4%	4%	16.4	54.7	28.1	19.6	13.2	38.3	11.7	0.0
28/07/2023	0%	100%	58%	0%	15.9	138.0	49.8	30.9	12.7	0.0	33.9	15.0
3/08/2023	8%	67%	0%	4%	14.6	27.1	31.6	20.3	15.9	12.5	17.0	0.0
9/08/2023	8%	88%	21%	0%	19.6	26.1	53.2	22.0	17.1	6.5	36.1	2.4
15/08/2023	21%	58%	4%	42%	8.0	6.6	4.1	3.9	9.8	0.0	0.0	0.0
21/08/2023	8%	92%	38%	0%	10.3	20.2	32.6	14.1	3.4	9.9	22.3	3.8
27/08/2023	0%	67%	0%	21%	10.4	11.4	29.6	9.3	14.1	0.0	19.3	0.0
2/09/2023	8%	75%	0%	38%	14.2	12.5	38.6	13.3	20.3	0.0	24.4	0.0
8/09/2023	0%	100%	79%	0%	6.6	8.7	7.2	10.5	4.1	0.0	0.6	3.9
14/09/2023	0%	83%	0%	25%	22.6	30.8	54.2	23.0	41.1	0.0	31.2	0.0
20/09/2023	0%	100%	25%	0%	36.5	86.4	124.0	73.7	40.0	0.0	87.5	33.7
26/09/2023	4%	79%	0%	8%	31.1	50.3	65.8	42.9	31.1	0.0	15.5	0.0
2/10/2023	4%	75%	4%	33%	48.8	44.8	81.0	41.6	51.6	0.0	29.9	0.0
8/10/2023	0%	79%	0%	38%	15.1	10.9	16.6	7.9	17.3	0.0	1.5	0.0
14/10/2023	0%	96%	67%	0%	14.4	37.2	24.6	47.2	7.0	0.0	10.2	32.8
20/10/2023	0%	92%	0%	4%	22.0	34.8	44.9	22.0	28.3	0.0	22.9	0.0
26/10/2023	0%	50%	0%	21%	15.0	12.3	18.2	10.8	13.9	0.0	3.2	0.0
1/11/2023	0%	100%	0%	63%	23.6	20.3	23.7	19.1	27.7	0.0	0.1	0.0
7/11/2023	4%	63%	0%	21%	9.3	10.6	23.6	7.2	15.9	0.0	14.3	0.0

Date	Percentage of time downwind (%)					24-hour a	werage PM10 lev	HVO South's estimated max. contribution to $PM_{10} \mbox{ level } (\mu g/m^3) \label{eq:max}$				
13/11/2023	0%	96%	0%	79%	29.7	26.5	26.8	23.8	34.9	0.0	0.0	0.0
19/11/2023	0%	96%	4%	25%	21.7	19.6	41.6	16.2	30.6	0.0	19.9	0.0
25/11/2023	0%	79%	13%	13%	7.5	7.4	9.9	6.9	7.5	0.0	2.4	0.0
1/12/2023	0%	100%	67%	0%	19.4	22.3	18.6	17.2	8.3	0.0	0.0	0.0
7/12/2023	0%	100%	8%	33%	32.3	44.7	47.5	36.0	43.5	0.0	15.2	3.7
13/12/2023	4%	79%	4%	29%	34.2	39.0	49.6	34.2	37.5	0.0	15.4	0.0
19/12/2023	4%	88%	17%	17%	47.8	63.8	83.9	63.0	56.4	0.0	27.5	6.6
25/12/2023	4%	54%	0%	25%	13.9	10.8	12.3	13.4	8.9	0.0	0.0	0.0
31/12/2023	0%	100%	0%	48%	20.8	13.4	15.0	13.4	19.5	0.0	0.0	0.0

- No data

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Appendix C

24-hour Average Levels and Estimated Contributions -**PM**_{2.5}



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Date Site		Measured 24-hour average PM _{2.5} level (µg/m³)	HVO South 24-hour average PM _{2.5} Incremental Criteria (μg/m³)	Estimated HVO South Incremental contribution to PM _{2.5} level (µg/m ³)
17/01/2023	Kilburnie South HVAS	29.2	25	11.0
16/02/2023	Kilburnie South HVAS	30.0	25	5.4
6/03/2023	Maison Dieu HVAS	43.2	25	22.7
18/03/2023	Kilburnie South HVAS	35.9	25	1.7
14/09/2023	Kilburnie South HVAS	27.2	25	4.7
20/00/2022	Kilburnie South HVAS	44.9	25	0.0
20/09/2023	Maison Dieu HVAS	43.7	25	0.0
2/10/2023	Kilburnie South HVAS	31.9	25	4.0
7/12/2023	Kilburnie South HVAS	43.1	25	6.0
12/12/2022	Kilburnie South HVAS	27.1	25	1.0
13/12/2023	Maison Dieu HVAS	28.7	25	1.0
10/12/2022	Kilburnie South HVAS	45.6	25	4.1
19/12/2023	Maison Dieu HVAS	46.0	25	15.7

Table C-1: Detailed analyses for elevated 24-hour average PM_{2.5} readings

Table C-2: 24-hour average PM_{2.5} HVAS levels, percent time downwind and estimated contributions – HVO South

Date	Percentage of time downwind of HVO South (%)		24-hour average PM _{2.5} level (μg/m³)			HVO South's estimated max. contribution to PM2.5 level (μg/m³)	
	Maison Dieu	Kilburnie South	Background	Maison Dieu	Kilburnie South	Maison Dieu	Kilburnie South
5/01/2023	0%	4%	6.5	3.9	9.1	0.0	0.0
11/01/2023	0%	42%	6.6	6.6	22.4	0.0	15.8
17/01/2023	0%	54%	3.9	3.9	29.2	0.0	11.0
23/01/2023	0%	29%	8.0	8.0	15.5	0.0	7.5
29/01/2023	8%	21%	7.9	17.1	20.9	9.2	13.0
4/02/2023	67%	0%	23.8	-	23.8	-	0.0
10/02/2023	8%	17%	6.3	17.0	16.2	10.8	10.0
16/02/2023	0%	33%	3.4	10.5	30.0	0.0	5.4
22/02/2023	0%	8%	3.1	3.1	1.1	0.0	0.0
28/02/2023	0%	29%	6.5	6.5	10.9	0.0	4.4
6/03/2023	17%	4%	20.5	43.2	2.9	22.7	0.0
12/03/2023	25%	33%	9.3	0.1	2.0	0.1	2.0
18/03/2023	8%	8%	11.1	2.3	0.5	2.3	1.7
24/03/2023	8%	38%	4.1	0.0	2.7	0.0	2.7
30/03/2023	67%	0%	3.8	7.8	0.0	7.8	0.0
5/04/2023	4%	33%	2.9	1.3	3.9	1.3	3.9
11/04/2023	8%	0%	6.0	0.1	0.0	0.1	0.0
17/04/2023	4%	33%	4.7	0.1	2.6	0.1	2.6
23/04/2023	0%	8%	3.7	0.0	0.5	0.0	0.5

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Date	Percentage of time downwind of HVO South (%)		24-hour average PM _{2.5} level (μg/m³)			HVO South's estimated max. contribution to PM _{2.5} level (μg/m³)	
	Maison Dieu	Kilburnie South	Background	Maison Dieu	Kilburnie South	Maison Dieu	Kilburnie South
29/04/2023	25%	4%	14.6	1.7	0.0	1.7	0.0
5/05/2023	4%	4%	8.2	0.3	0.3	0.3	0.3
11/05/2023	4%	17%	6.4	0.0	0.9	0.0	0.9
17/05/2023	8%	13%	6.7	0.1	0.4	0.1	0.4
23/05/2023	0%	8%	10.0	0.0	0.7	0.0	0.7
29/05/2023	58%	0%	3.9	8.3	0.0	8.3	0.0
4/06/2023	0%	42%	3.5	0.0	1.5	0.0	1.5
10/06/2023	25%	4%	2.8	0.3	0.4	0.3	0.4
16/06/2023	4%	0%	1.7	0.0	0.0	0.0	0.0
22/06/2023	13%	13%	11.5	0.0	0.0	0.0	0.0
28/06/2023	46%	0%	2.8	1.2	0.0	1.2	0.0
4/07/2023	4%	17%	8.2	0.0	0.2	0.0	0.2
10/07/2023	58%	0%	3.0	1.6	0.0	1.6	0.0
16/07/2023	13%	4%	3.4	0.1	0.0	0.1	0.0
22/07/2023	4%	4%	9.7	0.0	0.6	0.0	0.6
28/07/2023	50%	0%	5.2	5.2	0.0	5.2	0.0
3/08/2023	0%	4%	8.1	0.0	0.0	0.0	0.0
9/08/2023	17%	0%	5.2	0.0	0.0	0.0	0.0
15/08/2023	4%	42%	3.3	0.0	0.9	0.0	0.9
21/08/2023	33%	0%	1.0	0.0	0.0	0.0	0.0
27/08/2023	0%	21%	7.4	0.0	0.0	0.0	0.0
2/09/2023	8%	38%	4.0	0.0	0.3	0.0	0.3
8/09/2023	75%	0%	1.8	1.1	0.0	1.1	0.0
14/09/2023	0%	25%	8.9	0.0	1.5	0.0	4.7
20/09/2023	17%	0%	44.9	4.4	0.0	0.0	0.0
26/09/2023	8%	8%	7.5	0.0	1.2	0.0	1.2
2/10/2023	4%	33%	15.8	0.3	3.0	0.3	4.0
8/10/2023	0%	38%	4.2	0.0	4.6	0.0	4.6
14/10/2023	67%	0%	4.9	5.0	0.0	5.0	0.0
20/10/2023	0%	4%	5.8	0.0	0.0	0.0	0.0
26/10/2023	0%	21%	4.1	0.0	0.3	0.0	0.3
1/11/2023	0%	63%	5.9	0.0	1.4	0.0	1.4
7/11/2023	0%	21%	2.6	0.0	0.0	0.0	0.0
13/11/2023	0%	79%	7.6	0.0	1.9	0.0	1.9
19/11/2023	4%	25%	8.5	0.0	1.7	0.0	1.7
25/11/2023	13%	13%	4.3	0.0	0.3	0.0	0.3
1/12/2023	50%	0%	6.1	1.7	0.0	1.7	0.0
7/12/2023	4%	33%	13.0	0.0	43.1	0.0	6.0

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Date Percentage of time downwind of HVO South (24-hour average PM _{2.5} level (μg/m³)			HVO South's estimated max. contribution to PM _{2.5} level (μg/m³)	
	Maison Dieu	Kilburnie South	Background	Maison Dieu	Kilburnie South	Maison Dieu	Kilburnie South
13/12/2023	4%	29%	7.9	2.2	5.2	1.0	1.0
19/12/2023	8%	17%	22.3	0.0	1.6	15.7	4.1
25/12/2023	0%	25%	10.6	0.0	0.2	0.0	0.2
31/12/2023	0%	48%	3.1	0.0	0.2	0.0	0.2

- No data

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APPENDIX B: ANNUAL GROUNDWATER REVIEW

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HUNTER VALLEY OPERATIONS

2023 GROUNDWATER ANNUAL REVIEW

FINAL

March 2024

HUNTER VALLEY OPERATIONS

2023 GROUNDWATER ANNUAL REVIEW

FINAL

Prepared by Umwelt (Australia) Pty Limited on behalf of Hunter Valley Operations Pty Ltd

Project Director:Claire StephensonProject Manager:Kirsty CookseyTechnical Director:Claire StephensonTechnical Manager:Claire StephensonReport No.21188/R15Date:March 2024





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- Appendix B Groundwater Level Data
- Appendix C Groundwater Level Graphs
- Appendix D Groundwater Quality Data
- Appendix E Groundwater Quality Graphs
- Appendix F Comprehensive Groundwater Quality Results



1.0 Introduction

1.1 Overview

The Hunter Valley Operations (HVO) coal mining complex is located approximately 24 km northwest of Singleton, NSW. HVO is comprised of multiple open cut pits within the HVO North and HVO South operations, separated by the Hunter River. Mining is currently being undertaken in Cheshunt Pit and Riverview Pit, West Pit and Mitchell Pit, with additional pre-strip occurring in Mitchell Pit and West Pit.

The Hunter Valley Operations Water Management Plan (WMP) (V3) (HVO, 2018) dated 16 October 2018 covers approval commitments in Project Approvals:

- DA 450-10-2003 (Schedule 3, Condition 27) for HVO North.
- PA 06_0261 (Schedule 3, Condition 27 and 28) for HVO South.
- Individual bore license conditions (20BL173587-89, 20BL173847 and 20BL173392).
- Conditions of Environment Protection Licence 640.

This includes requirements for the monitoring of groundwater, assessment of potential impacts and reporting. As part of compliance with mine approval conditions, routine groundwater monitoring is conducted across HVO, and the data reviewed and analysed on a quarterly basis.

This report summarises the groundwater level and quality results for monitoring completed between 1 January and 31 December 2023 (the reporting period).

Umwelt have been engaged to undertake the annual review of the groundwater monitoring data collected during the reporting period. This report presents a summary of the groundwater data collected, high level discussion on any missing data or trigger exceedances, and recommendations (where relevant). This report has been developed in accordance with the approval conditions and requirements outlined within the 2018 WMP (HVO, 2018).

1.2 Scope

This report presents:

- Site background:
 - \circ $\;$ Legislative requirements and conditions relevant to groundwater.
 - Mine activities over reporting period.
 - Hydrogeological regime.
 - Groundwater monitoring network and programme.



- Data review:
 - Review and illustration (i.e., hydrographs) of groundwater level trends.
 - Review and illustration (i.e., hydrographs) of groundwater quality trends.
 - Comparison of water level and quality trends to relevant trigger levels and natural trends (i.e., surface water levels and rainfall).
 - Assess compliance with mine approval conditions and present a checklist summarising findings.
- Discussion of groundwater impacts and compliance over the reporting period and provision of recommendations.



2.0 HVO Complex

The following section provides a description of the HVO Complex relevant to this annual groundwater review. The site layout is shown in **Figure 2.1**.

2.1 Mine Operations

The mine areas across HVO, approved mining timeframes and activities undertaken over 2023, are summarised in **Table 2.1**. During 2023, active mining was undertaken in Cheshunt Pit and Riverview Pit, West Pit and Mitchell Pit, with additional pre-strip occurring in Mitchell Pit and West Pit.

Mine Area		Approved Life of Mining	Target Seam	Activities in 2023
HVO North	Alluvial Lands	1993 to 2003	Vaux	Inactive, fully rehabilitated
	Carrington Pit	2000 to 2025	Bayswater	Inactive, used for tailings storage and water storage
	Carrington West Wing	2023 to 2025	Bayswater	Not commenced
	Glider Pit	2016 to 2017	Vaux	Inactive, fully rehabilitated
	North Pit	1979 to 2003	Vaux	Inactive, converted to TSF
	West Pit (Includes Wilton and Mitchell Pits)	1949 to 2025	Bayswater to Hebden	Active mining
HVO	Cheshunt Pit	2002 to 2030	Bayswater	Active mining in Pits 1 & 2
South	Riverview Pit	1997 to 2030	Bayswater	Active mining
	Lemington mine (Underground)	1971 to 1992	Mt Arthur	Inactive
	South Lemington Pit 1	1998 to 2024	Bowfield	Inactive, used for water storage
	South Lemington Pit 2	2015 to 2030	Vaux	Not commenced

Table 2.1 HVO Activities

Table 2.2 summarises the tailings storage facilities (TSF) across HVO. The TSF's are managed in accordance with the site Fine Rejects Management Strategy, including decant requirements to enable consolidation of the material.

Table 2.2 Approved Talling Storage Facilities Summary	Table 2.2	Approved Tailing Storage Facilities Summar	y
-------------------------------------------------------	-----------	---------------------------------------------------	---

Mine Area	Location	Status
Dam 6W	West Pit Active (intermittent deposition).	
Bobs Dump TSF (20W)	West Pit	Capping and rehabilitation yet to commence.
North Void TSF (29N)	North Pit	Inactive, ceased receiving tailings in 2019. Decommissioning and management of decant pond commenced.



Mine Area	Location	Status			
South East TSF (27N)	North Pit	Capping and rehabilitation complete.			
Central TSF (28N)	North Pit	Inactive.			
Carrington Out of Pit Fine Reject Emplacement (COOP FRE)	Carrington area – out of pit emplacement	Approved but not constructed.			
Carrington In Pit Fine Reject Emplacement (FRE)	Carrington area – in pit emplacement	Active, receiving tailings since 2019.			
Cumnock Void TSF	Ravensworth	Active. On Ravensworth land and Glencore's responsibility.			
West Pit	West Pit	Approved but not constructed.			
Lemington 1 TSF Cell A	Lemington South	Rehabilitated.			
Lemington 1 TSF Cell B	Lemington South	Rehabilitated.			
Lemington 2 TSF	Lemington South	Rehabilitated.			
Lemington 3 TSF	Lemingtion South	Rehabilitated.			
Lemingotn 4 TSF Cell A Lemington South		Rehabilitated.			
Lemington 4 TSF Cell B	Lemingtion South	Rehabilitated.			
Lemington 5 TSF	Lemington South	Rehabilitated.			
Howick TSF	West Pit	Rehabilitated.			
Eastern TSF	North Pit	Rehabilitated.			
Western TSF Cell A	West Pit	Rehabilitated.			
Western Cell TSF Cell B	West Pit	Rehabilitated.			

During 2023 only Carrington In Pit Fine Reject Emplacement was actively used for tailings storage. North Void ceased receiving tailings in January 2019; decommissioning has commenced.

Groundwater was abstracted from the Lemington Underground Bore (LUG) during 2023. LUG Bore is a production bore constructed into the historical Lemington Underground beneath HVO that mined the Mt Arthur Seam of the Whittingham Coal Measures, with this mine having been inactive since 1999. Abstraction from LUG Bore is managed by Yancoal for the Mt Thorley Warkworth (MTW) operations.



FIGURE 2.1

Site Layout



- Barrier Walls
- Road
- Mapped Watercourses (named)
 Mine Areas

0

GOSFORD

MAITLAND NEWCASTLE

1 Kilometres

Scale 1:85,000 at A4 GDA2020 MGA Zone 56





2.2 Groundwater Impact Predictions

Groundwater impacts associated with the approved operations at HVO have been progressively assessed for each mining area, including:

- Alluvial Lands Project Groundwater Assessment (MMA, 1992).
- Carrington Pit Groundwater Assessment (MER, 1998).
- West Pit Extension Groundwater Assessment (MER, 2003).
- Carrington Pit Extended Groundwater Assessment (MER, 2005).
- Carrington West Wing Groundwater Assessment (MER, 2010).
- HVO South Groundwater Assessment (ERM, 2008).
- HVO North Modification 4 Groundwater Assessment Carrington Out of Pit Fine Reject Emplacement (AGE, 2013b).
- HVO North Modification 6 Groundwater Assessment Carrington In Pit Fine Reject Emplacement (AGE, 2016).
- HVO South Modification 5 Groundwater Assessment (AGE, 2017).
- HVO Continuation Project Groundwater Assessment (AGE, 2022).

2.2.1 Groundwater Assessment for Current Approval

The Environmental Assessment prepared for HVO South Modification 5 includes a groundwater assessment completed by AGE (2017). The groundwater assessment included development of a numerical groundwater model to represent groundwater response to approved mine activities and the proposed modification.

The approved operations included mining at Cheshunt Pit, Riverview Pit, Glider Pit and West Pit, as well as surrounding non-HVO mining operations (i.e., Ravensworth, United Wambo and Mt Thorley Warkworth) and abstraction from the LUG Bore. The model also included approved mining at Carrington West Wing until 2021; however, no mining has occurred at Carrington West Wing to date.

The model was calibrated to the end of 2015 and groundwater conditions and groundwater response to approved mining to the end of 2015, as reported by AGE (2017), indicated:

- Groundwater within the hard rock units is directly intercepted by approved operations at HVO.
- Groundwater within the confined to semi-confined Permian coal measures became depressurised around the area of active mining. Groundwater drawdown responses were observed around 2 km to 6 km from active mine areas within the Permian coal measures.
- There is no direct interception of groundwater within alluvium for active mine operations at HVO. However, historically the South Lemington Pit 1 footprint did directly intercept alluvium and barrier walls were established at Alluvial Lands and Carrington Pit to separate mine areas from alluvium.



- With depressurisation of the coal measures, the model predicted a reduction in upward seepage to the alluvium that was referred to as 'indirect take'.
- These findings largely aligned with historical groundwater assessments conducted for the approved operations across HVO. Groundwater licenses have been obtained for the approved operations, as discussed in Section 2.4. Management and monitoring requirements of potential groundwater related impacts from approved operations are captured within the development consent conditions. Schedule 3, Condition 27 of Development Consent (DA 450-10-2003) for HVO North, last updated January 2017 for Modification 6 and again in July 2017 (no changes to groundwater conditions in July 2017).
- Schedule 3, Condition 28 of the Project Approval (PA 06_0261) for HVO South, last updated October 2012.

These conditions are addressed within the site WMP. Further discussion on the monitoring and management requirements is included within **Section 2.3**.

2.3 Groundwater Approval Conditions

In accordance with the development consent approval conditions, HVO are required to prepare and implement a WMP to the satisfaction of the Secretary. **Table 2.3** presents a summary of the relevant groundwater conditions from the development consent and WMP. The table identifies where the conditions relating to routine groundwater monitoring for 2023 have been addressed.

Approval Condition	Condition	Where Addressed
Sch. 3, Cond. 27(c) (PA 06_0261)	A groundwater monitoring programme that includes:	
	• Additional baseline data of groundwater levels yield and quality in the region, and privately-owned groundwater bores, which could be affected by the project;	See WMP. No private bores predicted to be impacted for current approved operations and no monitoring of private bores.
	 Groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts of the project; and 	See Section 4.3 for criteria Section 6.0 comparison to triggers.
	 A programme to monitor: Groundwater inflows to the open cut mining operations; and 	See WMP.
	 Impacts of the project on the region's aquifers, any groundwater bores, and surrounding watercourses, and in particular, the Hunter River and Wollombi Brook and adjacent alluvium; and 	See Section 6.0.

 Table 2.3
 Groundwater Conditions Addressed Within WMP



Approval Condition	Condition	Where Addressed			
Sch. 3, Cond. 27(c) (DA450-10-2003)	A Groundwater Management Plan, which includes:				
	• Detailed baseline data on groundwater levels, yield and quality in the region, and privately- owned groundwater bores, that could be affected by the development;	See WMP.			
	• Groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;	See Section 4.3 for criteria Section 6.0 comparison to triggers.			
	• A programme to monitor:				
	 Groundwater inflows to the open cut mining operations; 	See WMP.			
	 the impacts of the development on: The alluvial aquifers, including additional groundwater monitoring bores as required by NOW; 	See Section 5.1.			
	 The effectiveness of the low permeability barrier; 	See Section 5.3.			
	 Base flows to the Hunter River; 	Groundwater trends reviewed in Section 5.0.			
	 Any groundwater bores on privately- owned land that could be affected by the development; 	No private bores predicted to be impacted for current approved operations and no monitoring of private bores.			
	 Groundwater dependent ecosystems, including the River Red Gum Floodplain Woodland EEC located in the Hunter River alluvium; 	See WMP.			
	 The seepage/leachate from water storages, backfilled voids and the final void; 	See Section 5.3 – including discussion on groundwater trends within North Pit spoil.			
	 The development, including an independent review of the model, every three years and comparison of monitoring results with modelled predictions; and 	See Section 8.0.			
	 A plan to respond to any exceedances of the groundwater assessment criteria. 	See Section 9.2.			
Sch. 3, Cond. 27(c) (DA450-10-2003)	• A programme to validate and recalibrate (if necessary) the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions;	See Section 8.0.			



Approval Condition	Condition	Where Addressed
HVO South Statement of Commitments	 In addition to the mitigation measures undertaken at HVO for groundwater management, the following controls specific to the proposal will be implemented: Groundwater Flow To and From Rivers: development of protocols for monitoring and reporting of NOW stream gauge results to clearly record any reductions in flows that are attributed to mining. This will include monitoring Hunter River flows immediately up gradient and down gradient of the site. In addition, consideration will be given to tying in specific CNA water level recordings with 	See Surface Water Review.
	current NOW gauging locations;	See Section 5.1.3 .
	within alluvium between the Hunter River and the Cheshunt Pit; and	
	 measured groundwater elevations and river flow will be assessed against predictions to determine whether application of additional management measures is required; and 	See Section 8.0.
	 offset seepage to pits in accordance with regulatory requirements. 	See WMP.

Consent conditions for the approved Carrington West Wing extension (Modification 3) are also included in the WMP; however, there are no current plans to commence mining in this area in the near future.

Groundwater monitoring is conducted in accordance with the Groundwater Monitoring Programme outlined within Appendix A of the WMP. The programme outlines groundwater monitoring frequency, parameters to be tested and groundwater triggers for electrical conductivity (EC) and pH. This annual review is based upon the monitoring and reporting requirements documented within the October 2018 version of the WMP. However, an updated WMP was submitted by HVO to Department of Planning Housing and Infrastructure (DPHI) and is awaiting approval. Further discussion on the groundwater monitoring programme and triggers is included in **Section 4.0**.

2.4 Groundwater Licensing

Under the Water Act 1912 and Water Management Act 2000, sufficient water access licences (WAL) are required for approval of the mine developments. HVO holds sufficient licences for direct and indirect take associated with approved operations. Groundwater licenses held for HVO are outlined in **Table 2.4**.



License Number	Description	Water Sharing Plan	Water Source - Management Zone	Approved Extraction (ML)		
WAL40462	HVO Pit Excavations –	North Coast	Permian Coal Seams	2,400		
WAL40463	Alluvial Lands Bores	Fractured and Porous Rock		180		
WAL40466				460		
WAL41527	HVO North – Carrington Pit			700		
WAL41533	HVO North Pit Excavation			20		
WAL39798	Lemington Underground (LUG) Bore					
WAL18127	Carrington BB1	Hunter Unregulated and Alluvial Water	Hunter Regulated River Alluvial Water	383		
WAL18158	Ollenberry	Sources	Source – Upstream Glennies Creek Management zone	65		
WAL18307	HVO West – Parnells Creek Dam (Diversion Works Bywash)		Jerrys Management Zone	500		
WAL18327	HV Loading Point Pump Bayswater Creek (Diversion Works)			150		
WAL36190	HVO North, old farm bore			120		
WAL23889	Greenleek		Lower Wollombi Brook Water Source	144		
WAL962 (20AL201237)	Surface water access – West Pit area	Hunter Regulated River Water Source	Hunter River (Zone 1b) between Goulburn River junction and Glennies Creek junction.	3,165		
WAL970, WAL1006 & WAL1070 (20AL201256, 20AL201337 & 20AL201500)	Surface water access – HVO North and HVO South areas		Hunter River (Zone 2a) between Glennies Creek junction and Wollombi Brook junction.	1,500 (500 each)		

Table 2.4 Groundwater Licences Held by HVO



3.0 Environmental Setting

3.1 Climate

The climate within the HVO area is sub-tropical, with temperatures, rainfall and evaporation highest over the summer months of December to February. Daily rainfall data is collected at HVO at the site meteorological gauge HVO Corp. **Table 3.1** provides the historical average monthly rainfall data (2012 to 2023), as well as monthly data from site. During the reporting period the site recorded above average rainfall in February and December, with the remaining months recording below average rainfall.

Climate data was also obtained from the Scientific Information for Land Owners (SILO) database of historical climate records for Australia hosted by the Department of Environment and Science (DES). This service interpolates raw rainfall and evaporation records obtained from the Bureau of Meteorology (BOM), with data gaps addressed through data processing in order to provide a spatially and temporally complete climate dataset.

Climate data was obtained for a SILO grid point (Latitude -32.50, Longitude 151.00) at HVO between 01/01/1900 to 31/12/2023. A summary of rainfall data for SILO is presented in **Table 3.1**. The rainfall data indicates below average rainfall throughout the year with the exception of March and December. From May to July rainfall was significantly lower than the historical average. Based on the SILO dataset, average annual rainfall is 633.7 mm. Rainfall over 2023 was below average with 500.5 mm recorded.

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Site Historical Average	79.0	72.6	113.2	41.6	20.0	35.8	39.2	35.0	33.4	46.6	75.6	65.8	657.8
Site 2023	56.6	86.2	62.0	33.6	1.2	10.8	9.4	34.8	15.0	34.6	45.2	69.6	459.0
SILO Historical Average	73.0	69.8	65.5	44.9	38.4	45.9	40.9	35.4	39.8	50.1	62.0	67.9	633.7
SILO 2023	58.2	67.9	92.4	41.8	2.9	15.9	10.3	29.9	14.5	37.9	46.5	82.3	500.5

Table 3.1 Monthly Rainfall (mm)

Long term climate trends in the HVO site (HVO Corp) rainfall data from 2012 to present are displayed using a cumulative rainfall departure (CRD) rainfall plot in **Figure 3.1**. The CRD graphically shows trends in recorded rainfall compared to long-term averages and provides a historical record of relatively wet and dry periods. A rising trend in slope in the CRD graph indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average. A level slope indicates average rainfall conditions. The area has generally experienced below average rainfall from 2016 until the end of 2019, with above average rainfall recorded from January 2020 to December 2022. Over the reporting period the site generally experienced below average rainfall. **Figure 3.2** shows that the SILO average monthly evaporation exceeds rainfall in all months.





Figure 3.1 Cumulative Rainfall Departure and Monthly Site Rainfall



Figure 3.2 Evaporation



3.2 Streamflow

The terrain and drainage at HVO are dominated by the easterly flowing Hunter River, which dissects the complex in a general east-west direction. Ground elevations range between 60 m Australian Height Datum (mAHD) along the Hunter River alluvial plains to 180 mAHD in the northern parts of HVO North and in the western parts of HVO South. Minor ephemeral drainage features are also present around HVO North (i.e., Parnells Creek, Farrells Creek and Bayswater Creek) and HVO South (Wollombi Brook), which drain into the Hunter River (SLR, 2020).

Real time stream flow data is monitored along the Hunter River and Wollombi Brook at WaterNSW gauging stations via the Hunter Integrated Telemetry System (HITS). Time series river water elevations (mean level above zero-gauge elevation) are shown in **Figure 3.3** for three HITS stations (Hunter River @ Liddell, Hunter River @ U/S Foy Brook and Wollombi Brook @ Warkworth). In addition, HVO monitors the Hunter River monthly at surface water sites WL03 and WL05, WL10 and WL14. However, data has only been collected from September to December 2023 due to access issues.

During the reporting period, stream elevations within the Hunter River ranged from 66.58 mAHD upstream at Liddell (210083), down to 49.46 mAHD at Foy Brook (210126). Levels remained relatively stable over 2023 in response to below average rainfall. Review of stream discharge for the Hunter River at Foy Brook indicates discharge rates peaked in June with the highest flow of 2,107 MLs/day recorded on the 9 June 2023.

During the reporting period, stream elevations within Wollombi Brook at Warkworth (210004) ranged between 48.84 mAHD and 49.72 mAHD. Stream discharge indicates flow within Wollombi Brook ranged from no flow to 275 ML/day (27 February) during the reporting period.



Figure 3.3 Surface Water Levels



3.3 Geology

HVO lies within the Hunter Coalfields, which are dominated by the Permian aged Whittingham Coal Measures of the Sydney Basin. The Whittingham Coal Measures are comprised of the Jerrys Plains Sub-group and Van Sub-group, which consist of coal seams with overburden and overburden (sandstone, siltstone, tuffaceous mudstone and conglomerate). The Whittingham Coal Measures are truncated to the east by the Hunter-Mooki Thrust Fault and occur at HVO as stratified (layered) sequences that dip at a shallow angle to the southwest. The coal seams subcrop to the north and east of the HVO complex (SLR, 2020). The Muswellbrook Anticline and the Bayswater Syncline are also present to the west and north and east of HVO, respectively (EMM, 2022).

The Whittingham Coal Measures are incised by a paleochannel of the Hunter River within HVO North. The properties and extent of the paleochannel were assessed and mapped by MER (2008). The paleochannel comprises heterogeneous distribution of silts, sands and gravels.

Quaternary alluvium, comprising surficial sediments of silts and clays, unconformably overlies the Permian coal measures along the Hunter River and Wollombi Brook. Along the Hunter River and Wollombi Brook, the surficial sediments overlie basal sands and gravels that are between 7 m to 20 m thick (SLR, 2020).

Within HVO North, mined out areas have been backfilled with spoil and fine rejects. The spoil consists of Permian interburden and overburden waste material (EMM, 2022).

The surface geology within the HVO complex is summarised in Table 3.2 and shown in Figure 3.4.

Age	Stratigraphic Unit		Description		
	Quaternary alluvial	Surficial alluvium (Qhb)	Shallow sequences of clay, silty sand and sand.		
Cainozoic	sediments (Qa)	Productive basal sand/gravel (Qha)	Basal sands and gravels along major watercourses (i.e., Hunter River and Wollombi Brook).		
	Silicified weathering	profile (Czas)	Silcrete.		
	Alluvial terraces (Cza)	Silt, sand and gravel.		
Jurassic	Volcanics (Jv)		Flows, sills and dykes.		
Permian Wh Me		Jerrys Plains Sub-group (Pswj)	Coal bearing sequences interbedded with sandstone and siltstone. Coal seams (youngest to oldest) include Whybrow, Redbank Creek, Wambo, Whynot, Blakefield, Glen Munro, Woodlands Hill, Arrowfield, Bowfield, Warkworth, Mt Arthur, Piercefield, Vaux, Broonie and Bayswater.		
	Whittingham Coal Measures	Archerfield Sandstone (Pswv)	Lithic sandstone marker bed.		
		Vane Sub-group (Pswv)	Coal bearing sequences interbedded with sandstor and siltstone. Coal seams (youngest to oldest) include Lemington, Pikes Gully, Arties Liddell, Barrett and Hebden.		
		Saltwater Creek Formation (Psws)	Sandstone and siltstone, minor coaly bands, siltstone at base.		

 Table 3.2
 HVO Generalised Stratigraphy (After: SLR, 2020)



FIGURE 3.4

Surface Geology

Legend

\mathbb{X}	Mine Areas
	Mapped Watercourses (named)
	Road
	Mapped Watercourses (named)
Surf	ace Geology
	Cz - Cainozoic Sediments
	Jv - Jurassic Volcanics
	Pgr - Rowan Formation
	Pmb - Branxton Formation
	Pmm - Mulbring Siltstone
	Pms - Muree Sandstone
	Psl - Newcastle Coal Measures
	Pswc - Saltwater Creek Formation
	Pswj - Jerry's Plains Subgroup
	Pswv - Archerfields Ss. Vane
	Subgroup

- Qa Quaternary alluvium Rn - Narrabean Group
 - water
- Named Waterbody





3.4 Groundwater Units

The main groundwater units at HVO and the surrounding area are the productive alluvium associated with the Hunter River and Wollombi Brook, and the Permian coal seams of the Whittingham Coal Measures. Groundwater unit information has been derived from historical groundwater assessment reports, summarised in **Section 2.2**.

3.4.1 Alluvium

The Quaternary alluvium is an unconfined groundwater system that is recharged by rainfall infiltration, streamflow and upward leakage from the underlying stratigraphy, particularly in undisturbed areas (i.e., away from active mining). The flow direction within the alluvium generally follows topography. (Groundwater within the Hunter River alluvium flows in an easterly direction, while water within the Wollombi Brook alluvium flows in a north to north-easterly direction towards the Hunter River (SLR, 2020).

Regionally, the Hunter River and Wollombi Brook predominantly gain water from the surrounding alluvium, as well as from rainfall and regulated flow. However, there are also areas with losing conditions where rivers recharge the underlying alluvium. These losing conditions can occur around areas of active mining, where the hydraulic gradient is increased due to depressurisation of the underlying coal measures. Losing conditions also occur within the more topographically elevated tributaries of the main water courses, where the water table is deeper and not connected directly to the streams (SLR, 2020).

The less productive groundwater within the surficial alluvium does not meet the ANZECC (2000) water quality guidelines for stock water supply. However, the water quality of the highly productive alluvium, which includes basal sands and gravels is considered suitable for stock water supply. However, most agricultural producers (crop and cattle) utilise surface water resources (Hunter River and Wollombi Brook) in preference to alluvial groundwater (SLR, 2020).

The alluvial aquifer of the Hunter River supports Carrington Billabong, an ephemeral freshwater wetland located south of Carrington Pit that is considered a Groundwater Dependant Ecosystem (GDE). Alluvial groundwater levels around Carrington Billabong have remained relatively stable during active mining at Carrington Pit. This is due to installation of a barrier wall through the unconsolidated alluvial sediments, which separates the Billabong from Carrington Pit. The stable alluvial groundwater levels in this area are also taken to indicate limited hydraulic connection between the nearby paleochannel alluvium and the underlying depressurised coal measures (SLR, 2020).

3.4.2 Permian Coal Measures

The Whittingham Coal Measures outcrop across the north and east of the HVO complex. The coal measures form unconfined groundwater systems at outcrop, becoming semi-confined to confined as they dip towards the southwest.



Recharge occurs from direct rainfall infiltrating into the formations through the thin soil cover and weathered profile. The coal measures also occur at subcrop in localised zones beneath the alluvium associated with the Hunter River and Wollombi Brook, where the unit is recharged by downward seepage where gradients induce flow. The coal seams are typically moderately to slightly permeable, with hydraulic conductivity of the interburden generally less than coal seams but more variable, depending on the predominance of fractures in the rock mass. The hydraulic conductivity of the coal seams generally decreases with depth due to the closure of the cleats with increasing stratigraphic pressure (SLR, 2020).

Groundwater flow direction within the Whittingham Coal Measures is influenced by the local geomorphology and structural geology. The long history of mining within the region has also significantly altered groundwater flow paths within the Permian units. On a regional scale, groundwater flow in the Permian aquifers follows topography, flowing in a north-easterly direction. On a local scale, groundwater levels show drawdown impacts associated with the extensive active mining areas. Groundwater discharge from the Whittingham Coal Measures occurs as discharge to active mining and abstraction bores, as well as upward seepage to the Quaternary alluvium where hydraulic gradients induce flow (SLR, 2020).

Due to the poor water quality of the Permian coal measures, that generally exceeds ANZECC (2000) water quality guidelines for stock supply, there is no significant usage of groundwater from the Permian coal measures. Stock supply is primarily derived from perennial surface water flows (Hunter River and Wollombi Brook) and the more productive alluvial aquifer (SLR, 2020).

3.5 Groundwater Dependent Ecosystems

The Groundwater Dependant Ecosystem (GDE) is one in which the plant and/or animal community is dependent on the availability of groundwater to maintain its structure and function, which can be classified into three broad types:

- Ecosystems dependent on the subsurface presence of groundwater (terrestrial GDEs, including some riparian vegetation communities).
- Ecosystems dependent on the surface expression of groundwater (aquatic GDEs, including river baseflow systems, springs and swamps).
- Aquifer and cave ecosystems (subterranean GDEs).

The GDE Atlas (BoM, 2022) classifies ecosystems based on the potential for dependence on groundwater, based on multiple lines of scientific evidence. Ecosystems are mapped as either:

- High potential for groundwater interaction (indicating a strong possibility the ecosystem is interacting with groundwater).
- Moderate potential for groundwater interaction.
- Low potential for groundwater interaction (indicating it is relatively unlikely the ecosystem will be interacting with groundwater and will include ecosystems that are not interacting with groundwater).



Within the HVO complex, ecosystems with the potential to rely on the surface or subsurface expression of groundwater include (EMM, 2022):

- The Hunter River, Wollombi Brook and their tributaries where groundwater provides baseflow to surface water.
- Shallow groundwater systems.
- Vegetation overlying shallow groundwater.

Potential GDE assessments have been undertaken for the HVO complex and have identified (EMM, 2022):

- Stygofauna within the Hunter River, Wollombi Brook and their tributaries.
- River Red Gums within the Carrington Billabong, near the Hunter River.
- River Oak Grassy Riparian Woodland in the Hunter River riparian zone.
- Warkworth Sands Woodland community within the South Lemington area (intermittently reliant on perched water table).



4.0 Groundwater Monitoring

4.1 Groundwater Monitoring Program

Groundwater monitoring is conducted at HVO in accordance with the WMP (HVO, 2018), which includes details on the Groundwater Management Plan and Groundwater Monitoring Program. The monitoring results are used to monitor trends in physical and geochemical parameters of groundwaters that are potentially influenced by mining.

The groundwater monitoring network at HVO is comprised of a series of monitoring bores and vibrating wire piezometers (VWPs), detailed in **Appendix A**. The groundwater monitoring network, outlined within the WMP, is comprised of 127 monitoring sites which includes 119 compliance monitoring bores and eight VWPs, as detailed in **Table 4.1**. Of the 119 compliance monitoring bores, 104 have water quality triggers and five have water level triggers defined. The groundwater monitoring network is presented in **Figure 4.1** to **Figure 4.3**.

In 2019, SLR undertook a network review which identified some changes in target geology compared to the WMP. The network review also assessed the condition and purpose of each bore and made recommendations to remove bores from the monitoring network that were damaged or destroyed, not providing representative groundwater data, where duplicate monitoring locations existed and where site activities have ceased. In 2023, Umwelt reviewed the draft WMP and made further recommendations on the monitoring network. Groundwater level and quality triggers were also reviewed, and the trigger levels were updated based on all historical data available and set based on geographical and target stratigraphy. The baseline data was used to update the 95th percentile for EC and 5th and 95th percentiles for pH. An updated groundwater monitoring program has been included in the draft WMP (version 3.4) which is currently with DPHIDPHI awaiting approval. For the purposes of annual reporting, the results are presented in comparison to the details in the current WMP (HVO, 2018) and, if exceedances recorded, discussed with reference to the revised monitoring programme recommendations.

Geology	Location	No. of Bores
	Carrington	5
	Carrington West Wing	9
Alluvium	Cheshunt/North Pit	17
	Lemington South	3
	West Pit	5
	Carrington	5
Permian coal measures	Carrington West Wing	2
	Cheshunt	13
	Lemington South	30
	Southern	12
	West Pit	11 (8 VWPs)
Snoil	Carrington	2
Shou	North Pit	13

Table 4.1 Groundwater Monitoring Network



Monitoring of groundwater levels and groundwater quality is undertaken at the bores detailed in the WMP (HVO, 2018), and defined below:

- Groundwater Level (127 bores):
 - Manual groundwater elevation/depth to groundwater measurements at a monthly (4), quarterly (94) or six monthly (29) frequency.
 - Monitoring bore data logger/VWP sensors download quarterly, and verification and validation of instrument drift and correction.
- Groundwater Quality Analysis Standard (119 bores):
 - Quarterly: field readings of water temperature, pH and electrical conductivity (EC).
- Groundwater Quality Analysis Comprehensive (65 bores):
 - Six Monthly (27) or Annually (38): the standard analysis with the addition of laboratory analysis of pH, EC, Total Dissolved Solids (TDS), Aluminium, Arsenic, Boron, Calcium, Cadmium, Chloride, Carbonate, Copper, Mercury, Potassium, Magnesium, Sodium, Nickel, Lead, Selenium, Sulphate, Zinc, Total Alkalinity, Bicarbonate Alkalinity, Carbonate Alkalinity, Hydroxide Alkalinity. Three of the six monthly monitoring bores (CHPZ1A, PZ2CH400 and PZ3CH800) require the following additional analyses: Beryllium, Cobalt, Fluoride, Iron, Manganese, Ammonia, Nitrite, Nitrate, Phosphorus, Rubidium, Antimony, Silica, Strontium.

Groundwater quality sampling is undertaken quarterly by external contractors AECOM in accordance with AS/NZS 5667.1:1998 (R2016) Guidance on the design of sampling programs, sampling techniques and the prevention and handling of samples and AS/NZ 5667.11:1998 (R2016) *Guidance on sampling of groundwater.* Field sheets, detailing the sample location, date, time, field EC, field pH and water level below top of casing are completed by AECOM during each monitoring round. The field sheets compiled by AECOM and results stored in HVO's EMD have been reviewed by Umwelt for this report.

4.2 Data Recovery

Groundwater level and quality data, along with field and lab sheets, were downloaded from the HVO site database (EMD) by Umwelt. As per the WMP, groundwater level monitoring and sampling is required to be carried out at 127 monitoring bores. Over 2023, monitoring of 123 bores was undertaken. Four bores were unable to be monitored throughout the year, either due to the bore being blocked (NPz3), bore mined out (NPz5), data unable to be downloaded due to failed VWP units (GW-103) or calibration information for data conversion unavailable (GW-110).

Monitoring bores with a data capture rate of less than 100 per cent are summarised in Table 4.2.



Bore ID	Type Not Measured	Data Recovery	Comments	
4034P	WQ	75%	Insufficient water to sample in Q1	
4036C	SWL, WQ	25%	Bore blocked in Q1, Q2 and Q3	
BZ3-1	WQ	50%	Dry, unable to sample in Q1 and Q2	
BZ4A(2)	WQ	75%	Insufficient water to sample in Q2, Q3 and Q4	
BZ8-2	SWL, WQ	50%	No access in Q2, insufficient water to sample in Q3 and Q4	
C122(BFS)	SWL, WQ	50%	No access due to flooding in Q1 and Q2	
CGW45	SWL, WQ	0%	Bore blocked	
D510(AFS)	SWL, WQ	50%	Dry, unable to sample in Q2, bore blocked in Q4	
D612(AFS)	WQ	75%	Dry, unable to sample in Q2	
DM3	WQ	50%	Bore blocked, unable to sample	
GW-101	WQ	50%	Dry, insufficient water to sample	
GW-103 (VWP)	SWL	0%	All sensors failed in 2020	
GW-107	WQ	50%	Dry, insufficient water to sample	
GW-108	SWL, WQ	0%	Bore blocked	
GW-110 (VWP)	SWL	0%	Calibration information unavailable for data conversion	
NPz3	SWL, WQ	0%	Bore blocked	
NPz5	SWL, WQ	0%	Mined through, no longer exists	
PZ1CH200	SWL, WQ	50%	No access in Q1 and Q2	
PZ2CH400	SWL, WQ	75%	No access in Q2	
PZ3CH800	SWL, WQ	75%	No access in Q2	
PZ4CH1380	SWL, WQ	75%	No access in Q2	
PZ5CH1800	SWL, WQ	75%	No access in Q2	

Table 4.2 Groundwater Monitoring Data Recovery – Compliance Bores





0.5

Kilometers

Scale 1:28,500 at A4

GDA2020 MGA Zone 56

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0.5





4.3 Groundwater Triggers

Groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts, are detailed in the WMP (HVO, 2018). These criteria are summarised in **Table 4.3**.

Table 4.3	Groundwater	Impact	Assessment	Criteria
		•		

Criteria	Description
1	The groundwater level does not decline more than 2 m at any privately owned bores and wells identified in the HVO complex EA's (with the exception of a single bore on land owned by the Ravensworth mine (10011459) which is predicted to decline by a maximum of 2.7 m).
2	Water quality does not lower the beneficial use category of the groundwater source beyond 40 m from the mining pit. This will be identified using groundwater triggers (EC) for individual monitoring bores specified in the Groundwater Monitoring Programme.
3	The alluvial groundwater source within 40 m of the recognised GDE communities does not experience more than a 10% reduction in piezometric levels predicted in the EA's for HVO North and HVO South (allowing for typical climatic variation).

Criteria 2 in **Table 4.3** relates to the trigger levels established for EC based on the 95th percentile, and the 5th and 95th percentiles for pH, of data collected from 2011 onwards (HVO, 2018). The trigger levels, as presented in the WMP (HVO, 2018) are summarised in **Table 4.4**. Groundwater quality data from the compliance monitoring bores have been compared to the trigger levels in **Section 6.0**.

Location	Target Stratigraphy	pH (5 th Percentile)	pH (95 th Percentile)	EC (µS/cm) (95 th Percentile)
Carrington	Alluvium	7.0	8.0	6,154
	Interburden (sandstone/siltstone)	6.7	7.4	10,824
	Broonie Seam	6.8	7.1	8,628
Carrington West Wing	Alluvium	7.0	7.5	2,775
	Bayswater	7.3	7.6	3,531
	LBL	6.5	7.2	1,894
Cheshunt	Mt Arthur Seam	6.5	7.6	3,350
	Interburden (sandstone/siltstone)	6.9	7.7	6,213
	Piercefield Seam	6.4	6.8	2,596
Cheshunt/North Pit	Alluvium	6.6	7.5	4,462
	Bowfield Seam	6.7	7.9	12,440
	Woodlands Hill Seam	6.6	7.6	20,240
	Arrowfield Seam	6.8	7.5	15,324
Lemington South	Alluvium	6.6	7.7	3,938
	Glen Munro Seam	6.7	7.1	11,408
	Interburden (sandstone/siltstone)	6.8	7.0	22,700

Table 4.4Groundwater Quality Trigger Levels


Location	Target Stratigraphy	pH (5 th Percentile)	pH (95 th Percentile)	EC (μS/cm) (95 th Percentile)
North Pit	Spoil	6.5	7.8	12,460
West Pit	Interburden (sandstone/siltstone)	6.9	8.0	13,428

The WMP (HVO, 2018) also includes individual groundwater level triggers for five bores in the Carrington alluvium, based on the 5th and 95th percentile of the available standing water level (SWL) data for each bore. The trigger levels are detailed in **Table 4.5**. The SWL triggers for the five alluvium bores were derived to meet the AIP criteria for GDE communities at HVO (HVO, 2018).

Table 4.5	Water Level Trigger Levels -	- Carrington Alluvium
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Bore	SWL Trigger (mAHD) (5 th Percentile)	SWL Trigger (mAHD) (95 th Percentile)
CFW55R	57.06	59.41
CFW57	58.24	59.24
CGW52a	58.23	60.52
CGW53a	58.33	59.19
CGW55a	57.49	58.43

A trigger exceedance is defined as three consecutive measurements of EC, pH or SWL that exceed trigger values specified in the WMP (HVO, 2018). An exceedance will trigger a site-specific investigation, which will determine the source and risk of impact on water quality, impacts to GDE communities and will be reported in the annual review (HVO, 2018).

In addition, triggers have been developed for the North Void Tailings Facility (NV TSF) assessment under the Environmental Protection Licence (EPL). Water level triggers were assigned to alluvial bores positioned within and just outside the extent of impacted groundwater. These triggers will supersede triggers outlined in **Table 4.5** and have been updated in the revised WMP which is with DPHI awaiting approval.

Similarly, groundwater level and groundwater quality triggers have also been revised for a number of other bores in the revised WMP (version 3.4) which is awaiting approval from DPHI.



5.0 Monitoring Results

A summary of the water level and water quality results is provided for each of the main water bearing units (alluvium, Permian coal measures and spoil) in **Section 5.1** to **Section 5.3**. Routine water level readings for 2023 are presented in **Appendix B** and historical trends are presented in **Appendix C**. Routine EC and pH readings and historical trends are presented in **Appendix E**, respectively.

Under the WMP (HVO, 2018), standard groundwater quality monitoring (pH and EC) is required quarterly for 80 of the monitoring bores within the network. In addition, groundwater quality samples are submitted quarterly to a laboratory for analysis of TDS, hydroxide alkalinity, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, sulphate, chloride, calcium, magnesium, sodium, potassium, and total and dissolved metals aluminium, arsenic, boron, cadmium, copper, mercury, nickel, lead, selenium, zinc. Additional analysis of beryllium, lithium, manganese, antimony, rubidium, strontium, iron, silica, fluoride, ammonia, nitrite, nitrate, phosphorus was undertaken for CHPZ1A, PZ2CH400, and PC3CH800. A summary of the water quality data is presented in **Appendix F**.

5.1 Alluvium

One bore was recorded as dry throughout 2023 (GW-101) and five bores were unable to be sampled in Q2 due to no access (PZ1CH200, PZ2CH400, PZ3CH800, PZ4CH1380 and PZ5CH1800).

Most alluvial bores recorded a general decrease in groundwater levels over 2023 in response to below average rainfall over the same period. Where saturated, groundwater within the alluvium occurred between 0.91 m (bore G2) and 20.17 m below surface (bore BUNC45a) over 2023. Discussion of groundwater level and quality trends within the alluvium is included for each of the mine areas from **Section 5.1.1** to **Section 5.1.4**.

5.1.1 West Pit

5.1.1.1 Groundwater Level Trends

Groundwater levels for the five alluvial/regolith bores north and northwest of West Pit are presented in **Figure 5.1**. Over 2023 groundwater elevations within the three bores (G1, G2 and G3) on the south-western side of Parnell's Creek Dam ranged between 106.63 mAHD (1.97 mbgl) and 109.69 mAHD (0.91 mbgl), in bores G3 and G2, respectively. Groundwater levels remained relatively stable over 2023.

Bores GW-100 and GW-101 are located along Parnell's Creek, downslope of the dam (18W). Groundwater levels within bore GW-100 decreased slightly over 2023. Review of the bore construction log indicates GW-100 is 6 m deep and has a screen from 4.4 m to 5 m below surface within gravels (colluvial deposit). Groundwater levels within bore GW-100 show a general decline since 2015 from 4.68 m below top of casing (TOC) to 6.21 mbTOC near the base of the bore in December 2019. Groundwater levels increased from January 2020 to 3.56 mbTOC in December 2022 in response to above average rainfall followed by a decline of 0.5 m over 2023 in response to below average rainfall.



Bore GW-101 was recorded as dry throughout 2023, a continuation of the trend over 2022. Bore GW-101 is 12 m deep and has a screen from 9 m to 12 m depth within clay. Bore GW-101 has recorded groundwater levels over 12 mbTOC and noted as dry or having insufficient water to sample since 2013. This may relate to the construction of the bore screen across low permeability clay.



Figure 5.1 Groundwater Levels – West Pit Alluvium

5.1.1.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.1.

Table 5.1 Summary of pH and EC Recorded Over 2023 – West Pit Alluvium

Screened Lithology	pH Range	EC Range (μS/cm)	Comment
Alluvium	7.2 – 7.8	10,560 – 11,060	Bore GW-100 recorded consecutive EC readings above the trigger level from April to December 2023 (Q2, Q3 and Q4), increasing from 10,560 μS/cm (Jan) to 11,060 μS/cm (Dec).

EC within the alluvial groundwater at bore GW-100 increased slightly over 2023 with concentrations ranging between 10,560 μ S/cm to 11,060 μ S/cm. Prior to 2023 EC concentrations remained relatively stable ranging between 9,570 μ S/cm and 11,510 μ S/cm.



5.1.2 Carrington and Carrington West Wing

5.1.2.1 Groundwater Level Trends

Groundwater levels for alluvial bores on the western limb of the paleochannel, near Carrington West Wing, are shown in **Figure 5.2**. Over 2023 groundwater elevations within bores 4032P, 4034P, 4037P, 4040P, and CGW49 in this area ranged between 59.93 mAHD and 61.65 mAHD (11.22 mbgl and 9.09 mbgl), in bores 4034P and 4037P respectively. Groundwater levels decreased slightly over 2023 in all five bores by approximately 1 m corresponding to decreased rainfall and stream flow trends.



Figure 5.2 Groundwater Levels – Carrington West Wing Alluvium (Western Limb)

Groundwater levels for bores within the floodplain alluvium on the northern end of the paleochannel (CGW32 and GW-106) and the two bores on the western limb of the paleochannel (CGW39 and CGW47a) near Carrington and Carrington West Wing are shown in **Figure 5.3**. Over 2023 groundwater elevations within the four bores in this area ranged between 59.52 mAHD (18.96 mbgl) and 61.48 mAHD (8.91 mbgl). Groundwater levels in bores CGW32 and GW-106 remained relatively stable over 2023. In comparison, levels in bore CGW39 decreased by 0.70 m and 0.91 m in bore CGW47a. Bores CGW32 and GW-106 are approximately 3 km north of the Hunter River, whereas bores CGW39 and CGW47a are 900 m north of the river and groundwater levels in these two bores decreased in response to below average rainfall and stream flow. It is also noted that the network review undertaken by SLR (2019) revised the screened lithology of bore CGW47a to the Broonie Seam and this has been updated in the revised WMP, which is awaiting approval.





Figure 5.3 Groundwater Levels – Carrington West Wing – Floodplain Alluvium (Western Limb)

Groundwater levels for the five bores within the alluvium on the eastern limb of the paleochannel near Carrington Pit are shown in **Figure 5.4**. The groundwater levels in all five bores, CFW55R, CGW53a, CFW57, CGW55a and CGW52a, decreased over 2023. Water levels decreased in four of the bores by up to 1 m. Water levels in bore CGW55a decreased by 2.89 m. Groundwater levels decreased in response to decreased rainfall and stream flow trends. Groundwater levels ranged between 58.74 mAHD (11.82 mbgl) and 61.63 mAHD (8.93 mbgl) in bore CGW55a.





Figure 5.4 Groundwater Levels – Carrington Alluvium

Existing groundwater monitoring bores located to the west of the NV TSF, are used to monitor groundwater levels and quality within the Carrington Billabong area and monitor the extent of impacts and response to management practices. Groundwater level triggers were assigned to five alluvial bores at Carrington; CFW55R, CFW57, CGW52a, CGW53a and CGW55a. Groundwater level graphs for each of the bores are compared to CRD in **Figure 5.5** and **Figure 5.9**.

Groundwater levels within all five bores decreased over 2023 in response to below average rainfall and stream flow. Groundwater levels in bores CFW57, CGW53a and CGW55a exceeded the 95th percentile trigger between mid to late 2021 and September 2023. Levels in CFW55R exceeded the 95th percentile trigger between May 2022 and June 2023. Groundwater levels in CGW52a did not exceed the trigger levels over 2023. The exceedances are discussed further in **Section 6.0**.



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-1500

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-2500

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Carrington Alluvium - CGW52a



61.0

60.5

60.0

59.5

59.0

58.5

58.0

57.5

57.0

Groundwater Elevation (mAHD)



500

0

131-22 120.23

Trigger SWL (5th)

CRD (SILO)

61.0

60.5

60.0

59.5

59.0

58.5

58.0

57.5

57.0

CEW57

Groundwater Elevation (mAHD)

Groundwater Levels – CFW57

Trigger SWL (5th) ---- Trigger SWL (95th) ----- CRD

Carrington Alluvium - CFW57





GW52

--- Trigger SWL (95th)



Figure 5.9 Groundwater Levels – CGW55a

Figure 5.8

Groundwater Levels - CGW53a



5.1.2.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.2.

Table 5.2Summary of pH and EC Recorded Over 2023 – Carrington and Carrington West Wing
Alluvium

Screened Lithology	pH Range	EC Range (μS/cm)	Comment
Carrington Alluvium	7.2 – 8.1	868 – 4,020	Bore CGW55a recorded one pH reading (8.1) above the upper trigger level in Q4.
Carrington West Wing Alluvium	6.8 – 7.6	1,153 – 9,400	Bore GW-106 recorded one EC reading (9,400 μS/cm) above the trigger level in Q3.

Bore CGW55a intersects alluvium within the eastern limb of the paleochannel near Carrington. Historical readings show that bore CGW55a has recorded pH ranging between 6.8 and 8.4. Over 2023 pH readings remained relatively stable and within historical levels. The results show no adverse impacts due to mining.

Bore GW-106 intersects a remnant patch of paleochannel alluvium between West Pit and Carrington Pit. Since monitoring commenced in September 2013, bore GW-106 has recorded EC ranging between 1,101 μ S/cm and 9,540 μ S/cm. The 2023 EC readings are within historical concentrations. The results show no adverse impacts due to mining.

5.1.3 Cheshunt Pit/North Pit

5.1.3.1 Groundwater Level Trends

Groundwater levels for bores within the alluvium north and south of the Hunter River, between North Pit and Cheshunt Pit are shown in **Figure 5.10**. Where the alluvium is saturated, groundwater levels ranged between 52.73 mAHD (20.17 mbgl) and 63.80 mAHD (1.65 mbgl), in bores BUNC45A and CHPZ4A, respectively. Over 2023, groundwater levels declined by up to 1.38 m (CHPZ8A) in response to below average rainfall and stream flows.

It is also noted that bore BZ1-1 is included in the current WMP as being within the alluvium; however, as identified in prior annual reviews (AGE, 2013a) the bore likely intersects interburden material. The target lithology has been updated in the revised WMP which has been submitted to DPHI for approval.





Figure 5.10 Groundwater Levels – Cheshunt/North Pit Alluvium

5.1.3.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.3.

Table 5.3	Summary of	pH and EC Recorded	l Over 2023 – Cheshunt	t and North Pit Alluvium

Screened Lithology	pH Range	EC Range (μS/cm)	Comment
Alluvium	6.5 – 7.7	141 – 3,180	Bore Hobdens Well recorded consecutive pH readings above the upper trigger level of 7.5, in Q2 (7.6), Q3 (7.7) and Q4 (7.6).
			Bore BUNC45A recorded a pH reading (6.5) below the lower trigger level in Q1.

Hobdens Well is screened within alluvium, located between the Hunter River and Cheshunt Pit. Historical readings show that Hobdens Well has recorded pH ranging between 7.1 and 8.2. Review of pH readings indicated levels fluctuated slightly, but within historical levels over 2023. The results show no adverse impacts due to mining. It is recommended the trigger level is updated to reflect historical trends.

Bore BUNC45A is screened within regolith, located between the backfilled Barrys Pit and the Hunter River. Groundwater pH within the bore has ranged from 6.5 to 7.1. A review of the groundwater data indicates levels have been at or just below the base of the screened interval between 2012 and 2021, and again in the latter half of 2023. Samples collected over 2023 may not be representative of the surrounding aquifer. For representative water quality samples, it is recommended that samples are not collected if the groundwater level is below 19.8 mbTOC which is 0.5 m above the base of the screen.



5.1.4 Lemington South

5.1.4.1 Groundwater Level Trends

Groundwater levels for four bores within the alluvium at Lemington South, along Wollombi Brook, are shown in **Figure 5.11**. Groundwater levels ranged from 45.25 mAHD (13.80 mbgl) to 49.92 mAHD (8.02 mbgl) in bores D317(ALL) and C919(ALL), respectively. Groundwater levels in the alluvium decreased over 2023 by up to 0.89 m (D317(ALL) and PB01(ALL)) in response to below average rainfall and stream flow.

Bore PB01(ALL) is located approximately 150 m from Wollombi Brook and bore Appleyard Farm is located 50 m west of Wollombi Brook and 1.2 km upstream of Lemington South Pit. The Wollombi Brook at Warkworth stream gauge is located approximately 350 m upstream of Appleyard Farm. Bores PB01(ALL) and Appleyard Farm declined over 2023. The groundwater level trends show a close correlation with decreasing stream flow levels and discharge for Wollombi Brook.

Bore D317(ALL) is located 45 m from Lemington South Pit, approximately 190 m from Wollombi Brook. Groundwater levels decreased by 0.89 m over 2023 in response to rainfall and streamflow.

Bore C919(ALL) is located 100 m east of Wollombi Brook and 200 m west of Lemington South Pit. Groundwater levels decreased over 2023 in response to below average rainfall.



Figure 5.11 Groundwater Levels – Lemington South Alluvium



5.1.4.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.4.

Screened Lithology	pH Range	EC Range (μS/cm)	Comment			
Alluvium	6.6 – 7.6	385 – 7,740	Bore PB01(ALL) recorded an EC reading (7,740 $\mu\text{S/cm})$ above the trigger level in Q4.			

Table 5.4 Summary of pH and EC Recorded Over 2023 – Lemington South

Bore PB01(ALL) is screened within alluvium, located on the northern banks of the Wollombi Brook, in an area with no active mining or land clearance. Historical readings show that PB01(ALL) recorded EC levels ranging between 205 μ S/cm and 13,640 μ S/cm. EC readings fluctuated over 2023 with an overall increase in response to declining groundwater levels but remained within historical levels.

Groundwater elevations in PB01(ALL) declined from 47.26 mAHD (7.11 mbgl) and 46.37 mAHD (8.00 mbgl) and trends generally correlate to changes in stream flow along Wollombi Brook. The groundwater level data is compared to trends for Wollombi Brook as recorded at HITS station Wollombi Brook @ Warkworth (Station 210004). **Figure 5.11** shows that water levels within bore PB01(ALL) roughly mimic water level trends within the Wollombi Brook. With decreased flow along Wollombi Brook due to below average rainfall over 2023 there has been an overall decrease in groundwater levels in PB01(ALL) of 0.89 m. The decline in groundwater levels has caused an increase in EC due to limited freshwater entering the bore. No adverse impacts due to mining have been identified.

5.2 Permian Coal Measures

Three bores in the Permian coal measures were recorded as blocked (CGW45, 4036C and NPz3) over 2023, with bore D510(AFS) recorded as blocked in Q4. Discussion on groundwater level and quality trends within the Permian coal measures is included for each of the mine locations from **Section 5.2.1** to **Section 5.2.4**.

5.2.1 West Pit

5.2.1.1 Groundwater Level Trends

Three bores (NPz2, NPz3 and NPz5) target the Permian coal measures at West Pit; however, bore NPz5 was mined out in 2020 and NPz3 was recorded as blocked.

Groundwater elevations for the bores at West Pit are presented in **Figure 5.12**. Groundwater levels within bore NP22 fluctuated over 2023. Between September and December 2023 levels declined by 4.7 m. A similar decline was recorded between September and December 2022, where levels declined by 6.08 m. The decline is unique to the bore and no known land use activities in the area that may have caused the decline. Bore NP22 is located upslope from West Pit, on the northwest side. Review of the geology mapped at bore NP22 identified that it intersects the Saltwater Creek Formation (Pswc). The Saltwater Creek Formation underlies the Vane Subgroup mined at West Pit. The Saltwater Creek Formation comprises laminated sequences of siltstone and sandstone, and the underlying Mulbring Siltstone comprises low permeability siltstone and claystone units and is considered to act as a confining unit (SLR, 2020).



The cause of the groundwater trend at NPz2 is unclear and would require further information regarding historical land use activities in the region. However, based on available information, the cause for the changes in groundwater levels do not appear to correlate to mine activities conducted at West Pit. Bore NPz2 has been removed from the compliance network within the draft WMP as the location and construction of the bore precludes it from providing an indication of potential impacts (SLR, 2019). The draft WMP has been submitted to DPHI for approval. It is recommended that the bore remains in the operational monitoring program to assist with future assessments and assessment of post closure groundwater conditions.

Bore NPz3 has been recorded as blocked since December 2022. In 2023, AECOM investigated the condition of the bore using a downhole camera. The footage showed major deformation of the PVC casing. It is recommended that the bore be replaced, as it will be required for monitoring of final voids following closure.



Figure 5.12 Groundwater Levels – West Pit Permian Coal Measures

Vibrating Wire Piezometers

In 2012, six VWPs were installed to monitor the coal seam and interburden sequences of the Permian coal measures in the West Pit area (GW-100a, GW-101a, GW-102, GW-103, GW-104 and GW-105), as summarised in **Table 5.5**. Over time a number of sensors within each VWP site have failed. With the exception of GW-103 and sensor VW3 in GW-105, which both failed in 2020, the VWPs were repaired in 2023 enabling data download.



VWPs GW-100a, GW-101a and GW-102 are located west of West Pit and south of Parnells Dam. GW-100a (Barrett Seam and interburden) recorded a slight decline while GW-101a (interburden) remained stable over 2023. GW-102 (interburden – sandstone with minor coal) fluctuated with an overall decline of 5.8 m over 2023 due to mining in West Pit. Groundwater level trends for the VWPs are presented in **Figure 5.13**.

VWPs GW-103, GW-104 and GW-105 are located south of West Pit. GW-104 VW1 (Lower Pikes Gully Seam), VW2 (interburden material) and VW3 (in sandstone above the Barrett Seam) all declined over 2023 due to depressurisation from mining at West Pit. GW-105 VW1 (Undifferentiated coal) and VW2 (Tuffaceous coal) also declined over 2023 due to mining at West Pit. Groundwater level trends for the VWPs are presented in **Figure 5.14**.

VWP ID	Sensor ID	Depth (mbgl)	Geology	Location	Comment
GW-100a	VW1	51.0	Barret Seam and Interburden	West of West Pit	Sensor replaced in May 2023. Overall, stable levels with a slight decline.
GW-101a	VW1	51.0	Interburden (siltstone/sandstone)	West of West Pit	New control unit installed in 2023 to enable data download. Overall, stable levels.
GW-102	VW1	60.5	Interburden (sandstone with minor coal)	West of West Pit	New control unit installed in 2023 to enable data download. Fluctuating levels with an overall decline since November 2022.
GW-103	VW1	25.5	Undifferentiated and weathered coal	South of West Pit	All sensors failed 20/01/2020.
	VW2	64.0	Siltstone and coal		
	VW3	119.5	Sandstone		
GW-104	VW1	59.0	Lower Pikes Gully Seam	South of West Pit	Relatively stable with a slight decline since January 2022.
	VW2	107	Sandstone near Upper Liddell Seam		Continued decline in levels since January 2019.
	VW3	135	Sandstone above Barrett Seam		Sharp decline in levels from July 2023.
GW-105	VW1	33.0	Undifferentiated coal	South of West Pit	Relatively stable since October 2020.
	VW2	103.5	Tuffaceous coal		Relatively stable between November 2019 and March 2023, followed by a slight decline.
	VW3	154.0	Coal		Sensor failed 17/02/2020.

Table 5.5 VWP Summary – West Pit





Figure 5.13 Groundwater Levels (VWPs) – West Pit Permian Coal Measures Near Parnells Dam



Figure 5.14 Groundwater Levels (VWPs) – West Pit Permian Coal Measures



5.2.1.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.6.

Screened Lithology	pH Range	EC Range (μS/cm)	Comment		
Sandstone/siltstone	7.0 – 7.0	13,620 – 14,410	Bore NPz2 recorded four consecutive EC concentrations above the trigger level over 2023.		

Table 5.6 Summary of pH and EC Recorded Over 2023 – West Pit Permian Coal Measures

Bore NPz2 is located approximately 4.5 km northeast of Plashett Reservoir and 1 km northwest of the West Pit mine area. The bore intersects interburden material (siltstone/sandstone) of the deeper Permian coal measures; with a screened interval between 57 mbgl to 60 mbgl. Historical EC readings for NPz2 since 2008 show regular fluctuations between 12,590 μ S/cm and 19,400 μ S/cm. The 2023 readings are considered consistent with historical concentrations. Although the 2023 EC readings are within the historical range, they are consecutive and therefore constitute and exceedance and this is discussed further in **Section 6.0**.

Based on available information, the cause for the changes in EC at NPz2 do not appear to correlate to mine activities conducted at West Pit. The network review undertaken by SLR in 2019 recommended that NPz2 be removed from the compliance network as the bore location and construction does not provide information on potential impacts related to site activities, and this has been undertaken in the draft WMP which is awaiting approval. This bore should continue to be monitored to assist with other assessments and post closure monitoring.

5.2.2 Carrington and Carrington West Wing

5.2.2.1 Groundwater Level Trends

The WMP includes seven monitoring bores with screens that intersect the Permian coal measures at Carrington and Carrington West Wing. This includes two bores within the Bayswater Seam (CGW45 and CGW46), two within the Broonie Seam (CGW52 and CGW53) and three within the interburden material (4036C, 4051C and CGW51a). Bore CGW45 was reported as blocked in Q1, Q3 and Q4 and bore 4036C was recorded as blocked in Q1, Q2 and Q3. Groundwater elevations for the seven bores are presented in **Figure 5.15**.

Bore CGW46 intersects the shallow Bayswater Seam underlying alluvium on the western limb of the paleochannel. Over 2023, groundwater levels ranged between 59.67 mAHD (12.28 mbgl) and 60.63 mAHD (11.32 mbgl), declining by 0.96 m over the year. The condition of the bore was investigated by AECOM in 2023. It is noted that the depth of the bore was measured at 51.80 m below surface. In addition, historically the casing above the ground surface has been damaged allowing ingress of surface water and debris. AECOM checked the bore with a downhole camera and noted the column of water within the bore was dirty and the screened interval was unable to be seen. The bore is cleaned and purged and the condition of the bore will be reassessed the next monitoring round.



Bore CGW45 intersects the Bayswater Seam at a depth of approximately 28 m. Over 2023, the bore was recorded as blocked with the exception of Q2 where the water level was recorded as 69.47 mAHD (2.36 mbgl). AECOM undertook an investigation of the bore condition in 2023. The investigation noted that the bore has been blocked since 2018. Historically the casing above ground had been damaged and was at ground level allowing surface water and debris ingress causing the blockage. Due to the bore condition CGW45 has been removed from the draft WMP which is awaiting approval. The bore should also be removed from the monitoring schedule.

Bores CGW52 and CGW53 both intersect the Broonie Seam and have recorded a rise in water levels since 2019, with the recovery in groundwater conditions following the cessation of mining at Carrington Pit. Over 2023, groundwater levels ranged between 35.82 mAHD (34.05 mbgl) and 38.46 mAHD (32.24 mbgl). Groundwater levels in both bores continued to rise over 2023 by 0.61 m in CGW53 and 1.09 m in CGW52.

Bores 4036C, 4051C and CGW51a are screened within interburden. Over 2023, groundwater levels declined and ranged between 40.64 mAHD (30.06 mbgl) and 58.69 mAHD (0.17 mbgl).

Bore 4036C has been recorded as blocked since December 2022. In 2023, AECOM investigated the condition of the bore with a downhole camera. The casing above the ground had been damaged, but was fixed during the investigation. The bore is blocked with organic matter and was removed; however, it was noted that there was significant sediment build up at the base of the bore and the water column within the bore was dirty. Bore 4036C has been removed from the draft WMP which is awaiting approval. It should also be removed from the monitoring schedule.

Construction details for bore CGW51a indicate it is screened within alluvium comprising fine to medium grained gravel and sand immediately overlying coal. As a result, groundwater within the bore is representative of alluvial groundwater and groundwater within the weathered coal measures. Due to the bore construction and potential for mixing, CGW51a has been removed from the draft WMP, which is awaiting approval. Bore CGW51a is used to monitor groundwater levels surrounding the backfilled Carrington Pit. Monitoring should continue to ensure the void continues to act as a groundwater sink. To enable this, it is recommended that a new bore be installed to replace CGW51a.





Figure 5.15 Groundwater Levels – Carrington Permian Coal Measures

Vibrating Wire Piezometers

In 2012, two VWPs were installed to monitor the coal seam and interburden sequences of the Permian coal measures west of Carrington Pit (GW-109 and GW-110), as summarised in **Table 5.7**. Groundwater level trends for the VWPs are presented in **Figure 5.16**.

Within GW-109, sensor VW3 (Bayswater Seam) failed in 2012, but was repaired in 2021. In addition, calibration details for GW-110 were not available at the time of reporting, therefore data could not be converted and graphed. However, GW-110 is located near the highwall within Carrington Pit void and may be decommissioned. Ongoing monitoring of groundwater level recovery in spoil material near Carrington Pit void can continue to be conducted at bores GW-107 and GW-108.

In GW-109, sensor VW1 (weathered coal) remained stable over 2023 following a slight decline in water levels since October 2021. Deeper sensor VW2 (tuffaceous coal) recorded a rise in groundwater levels at a lower elevation. The difference in the two sensors may relate to an additional source of recharge to the shallow stratigraphy. It is recommended that local site conditions be reviewed, and groundwater conditions within the spoil in Carrington Pit continue to be monitored. In addition, the status of sensor VW3 should be reviewed as trends indicate the sensor may be failing again.



VWP ID	Sensor ID	Depth (mbgl)	Geology	Location	Comment
GW-109	VW1	31.5	Weathered coal	West of Carrington Pit	Slight decline in levels since October 2021.
	VW2	65.0	Tuffaceous coal		Remained relatively stable since 2012 with a slight increase from May 2023.
	VW3	59.5	Bayswater Seam		Sensor failed between 2012, fixed in 2021. Levels have continued to increase sharply since July 2021.
GW-110	VW1	38.0	Sandstone	North ofCalibration dataCarrington Pitconvert raw data	Calibration data required to
	VW2	63.0	Sandstone		convert raw data.
	VW3	93.0	Bayswater Seam		

Table 5.7 VWP Summary – Carrington Area



Figure 5.16 Groundwater Levels (VWPs) – Carrington Permian Coal Measures

5.2.2.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.8.



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Screened Lithology	pH Range	EC Range (µS/cm)	Comment		
Carrington Interburden	6.7 – 8.3	1,105 — 6,040	Bore CGW51a recorded pH above the upper trigger level over 2023.		
Carrington Broonie Seam	6.6 – 7.1	5,550 – 7,950	Bore CGW53 recorded pH below the lower trigger level in Q1 (6.6) and Q3 (6.7).		
CWW Bayswater Seam	7.0 – 7.3	531 – 1,582	Bore CGW46 recorded pH below the lower trigger level in Q1 (7.0), Q2 (7.2) and Q4 (7.1).		

Table 5.8Summary of pH and EC Recorded Over 2023 – Carrington and Carrington West Wing
Permian Coal Measures

Bore CGW51a was identified to actually be screened within the alluvium by SLR (2020). As a result, groundwater within the bore is representative of alluvial groundwater and groundwater within the weathered coal measures. SLR (2020) recommended that due to the construction of the bore, it should be decommissioned to minimise potential mixing. Historical pH readings for the bore since 2005 show minor fluctuations of between 6.8 and 8.1. The 2023 readings increased from 7.7 (January) to 8.3 (December), moving above the historical range in December. The pH levels were consecutive readings above the trigger level of 7.4 and therefore constitutes an exceedance; this is discussed further in **Section 6.0**.

Bore CGW53 is located along the Hunter River, constructed with a screen from 38.5 m to 41.5 m below surface with 25 mm diameter casing, screened across coal (Broonie Seam). Historical pH readings for the bore since 2005 show regular fluctuations of between 6.6 and 7.8. The 2023 readings ranging from 6.6 to 6.7 are considered consistent with historical concentrations, with no adverse impacts identified.

Bore CGW46 is located approximately 900 m north of the Hunter River, screened across coal (Bayswater Seam). Historical pH readings for the bore since 2005 show regular fluctuations of between 7.1 and 7.8. The 2023 readings ranging from 7.0 to 7.3 are considered consistent with historical concentrations, with no adverse impacts identified. As noted in **Section 5.2.2.1**, the condition of the bore was investigated by AECOM in 2023, and cleaned and purged. The condition of the bore will be reassessed in the next monitoring round.

5.2.3 Cheshunt Pit/North Pit

5.2.3.1 Groundwater Level Trends

The WMP includes thirteen monitoring bores screened within the Permian coal measures at Cheshunt Pit. This includes nine bores within the Mt Arthur Seam (BC1a, BZ1-3, BZ2A(1), BZ3-3, BZ4A(2), CHPZ3D, CHPZ8D, CHPZ12D, HG2a), one within the Piercefield Seam (BUNC45D) and three within interburden (BZ3-1, BZ8-2 and HG2). Over 2023, bore BZ8-2 was recorded as collapsed in Q1, inaccessible in Q2 and dry in Q3 and Q4.

Groundwater elevations for the bores are presented in **Figure 5.17** to **Figure 5.19**. With the exception of bores CHPZ3D, CHPZ8D and CHPZ12D, groundwater levels within the Mt Arthur Seam remained relatively stable over 2023 ranging from 25.24 mAHD (46.15 mbgl) to 55.79 mAHD (4.10 mbgl) in bores BZ1-3 and CHPZ8D, respectively. Bores CHPZ3D, CHPZ8D and CHPZ12D, located over 1 km northeast of Cheshunt Pit, to the north of the rehabilitated Barry's Pit, recorded a decrease in groundwater levels of up to 1.4 m over 2023. Bore BUNC45D, located in the same area but screened within the Piercefield Seam, recorded a slight decline of 0.35 m over 2023.



Groundwater levels in bore BZ3-1, which intersects the Cheshunt Interburden, was recorded as dry in Q1 and Q2 and blocked at the start of Q3 (July). Once the blockage was removed water levels declined slightly by 0.33 m between August and December 2023. Groundwater levels within bore HG2, which is also screened within the Cheshunt Interburden, decreased by 0.9 m over 2023.



Figure 5.17 Groundwater Levels – Cheshunt Mt Arthur Seam





Figure 5.18 Groundwater Levels – Cheshunt Piercefield Seam



Figure 5.19 Groundwater Levels – Cheshunt Interburden



5.2.3.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.9.

Screened Lithology	pH Range	EC Range (μS/cm)	Comment
Interburden	6.8 - 7.5	2,690 – 3,830 Bores BZ3-1 recorded pH below the lower level in Q4 (6.8).	
Mt Arthur Seam	6.2 – 7.4	923 – 2,650	Bores BZ2A(1), BZ3-3, BZ4A(2) and CHPZ3D recorded pH ranging between 6.2 and 6.4. Only bore BZ3-3 recorded consecutive readings, constituting an exceedance.
Piercefield Seam	6.7 - 6.8	2,200 – 2,290	No exceedances

Table 5.9 Summary of pH and EC Recorded Over 2023 – Cheshunt Permian Coal Measures

Bore BZ3-1 intersects interburden and is located between Cheshunt Pit and the Hunter River. The range in historical data pH data ranges between 6.3 and 8.1. The 2023 pH reading of 6.8 is within the historical range.

Bores CHPZ3D, BZ2A(1), BZ3-3 and BZ4A(2) intersect the Mt Arthur Seam and are located between Cheshunt Pit and the Hunter River. The range in historical data for the three bores is 6.0 to 8.2. The 2023 pH readings for these bores are within the historical range. Only bore BZ3-3 recorded consecutive readings below the trigger level of 6.5 and therefore constitutes an exceedance; this is discussed further in **Section 6.0**.

5.2.4 Lemington South

5.2.4.1 Groundwater Level Trends

The WMP includes 29 monitoring bores with screen that intersects the Permian coal measures at Lemington South. This includes:

- Four bores within the Arrowfield Seam C130(AFS1), D406(AFS), D510(AFS) and D612(AFS).
- One bore within the shallow interburden material (siltstone/sandstone) C130(ALL).
- Eight bores within the Glen Munro Seam and/or Woodlands Hill Seam B425(WDH), B631(WDH), C122(WDH), C130(WDH), C317(WDH), C809(GM/WDH), D010(WDH) and D010(GM).
- Sixteen bores within the Bowfield Seam B334(BFS), B631(BFS), B925(BFS), C122(BFS), C130(BFS), C317(BFS), C613(BFS), C621(BFS), C630(BFS), D010(BFS), D214(BFS), D317(BFS), D406(BFS), D510(BFS), D612(BFS) and D807(BFS).

Groundwater level trends for bores targeting the Arrowfield Seam are presented in **Figure 5.20**. It is noted that bore D510(AFS) was recorded as dry in Q2 and blocked in Q4. Groundwater levels in bore C130(AFS) declined by 0.08 m compared to bore D406(AFS) which declined by 1.81 m over 2023. The decline in water levels in D406(AFS) is likely due to depressurisation due to active mining at the neighbouring United Wambo mine which is located 400 m to the west of the bore.





Figure 5.20 Groundwater Levels – Lemington South Arrowfield Seam

Groundwater level trends for bores targeting the shallow interburden, Woodlands Hill Seam and Glen Munro Seam are presented in **Figure 5.21**. With the exception of B425(WDH) and D010(GM), groundwater levels remained relatively stable with a slight decline over 2023.

Groundwater levels increased in bore D010(GM) by 6.47 m between November 2022 and May 2023. It was noted in the 2022 Annual Review (Umwelt, 2023a) that the rapid decline and then increase in groundwater levels is unique and may be due to an erroneous recording in November 2022.

Groundwater levels in bore B425(WDH) fluctuated by 2.5 m over 2023, ranging between 23.46 mAHD (34.42 mbgl) and 26.05 mAHD (31.83 mbgl). Following the decline of groundwater levels in bore B425(WDH) during 2017, the bore was recorded as dry between November 2017 and August 2022. These elevations and trends correspond more closely with trends observed for the Bowfield Seam bores. The 2019 network review undertaken by SLR recommended that the bore be removed from the monitoring network in favour of ongoing monitoring at nearby bore C130(WDH) (SLR, 2020). It is noted that B425(WDH) has been removed from revised WMP which is awaiting approval.





Figure 5.21 Groundwater Levels – Lemington South Woodlands Hill and Glen Munro Seams

Groundwater level trends for bores targeting the Bowfield Seam are presented in **Figure 5.22**. Over 2023, groundwater elevations ranged between -0.37 mAHD (58.57 mbgl) (C122(BFS)) and 41.91 mAHD (22.04 mbgl), in bores C122(BFS) and C630(BFS), respectively. Interpolated groundwater elevation contours for the Bowfield Seam are presented in **Figure 5.23**, based on November 2023 readings.

Groundwater levels in bores B334(BFS), C613(BFS), C630(BFS), D317(BFS) and D612(BFS) remained relatively stable over 2023. Bore C122(BFS), located to the west and furthest from Lemington South Pit, continued to remain dry.

With the exception of bores D214(BFS) and D010(BFS), groundwater levels in bores C621(BFS), C317(BFS), C130(BFS), B925(BFS), B631(BFS), D406(BFS), D510(BFS) and D807(BFS) declined by up to 7.4 m over 2023 in response to abstraction from LUG Bore. The bores are located from 300 m to 1.3 km north of LUG Bore.

LUG Bore intersects the historical Lemington Underground workings, which mined through the Bowfield Seam. Over 2023 (calendar year) 545 ML of water was abstracted from the bore, at an average rate of 1.5 ML /day. Groundwater elevations are higher in the northwest as shown in **Figure 5.23**, which illustrates groundwater flows towards LUG Bore from the northwest within a 1.3 km radius. This trend is visible in a range of bores intersecting the Permian coal measures in the area.

Bore D214(BFS) fluctuated over 2023, with groundwater levels ranging between 14.89 mAHD (41.78 mbgl) and 32.83 mAHD (23.84 mbgl). The fluctuations in groundwater levels were specific to bore D214(BFS) as surrounding bores screened within the Bowfield Seam did not record a similar trend. It is recommended the condition of the bore be investigated.



Bores D406(BFS), D510(BFS), D612(BFS) and D807(BFS) are located between Lemington South Pit and United Open Cut, over 2.5 km to the northwest of LUG Bore. With the exception of D010(BFS), groundwater levels declined by up to 4.36 m over 2023. The groundwater flow direction in this area is to the northwest away from LUG Bore and towards the United Open Cut. The declining trend likely relates to depressurisation of the coal measures from active mining within the United Open Cut, which is located approximately 700 m to the west of these bores. This is consistent with cumulative impacts predicted by AGE (2016).



Figure 5.22 Groundwater Levels – Lemington South Bowfield Seam

5.2.4.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.10.



Screened Lithology	pH Range	EC Range (µS/cm)	Comment
Interburden	Interburden 6.9 – 7.0 19,590 – 21,900		No exceedances.
Arrowfield Seam	6.9 – 7.4	11,040 - 13,000	No exceedances.
Bowfield Seam	6.2 – 7.9	113 – 12,860	Bore D214(BFS) recorded pH below the lower trigger level in Q2.
			Bore B631(BFS) recorded EC above the trigger level in Q4.
Glen Munro 6.9 9,290 - 11,470 Seam 9 9 9		9,290 – 11,470	Bore D010(GM) recorded EC above the trigger level in Q4.
Woodlands Hill Seam	6.5 – 7.8	5,130 – 20,800	Bore C122(WDH) recorded pH above the upper trigger level in Q2. Bores C130(WDH) and B631(WDH) recorded pH below the lower trigger level in Q4.
		Bore C130(WDH) recorded EC levels above the level in Q4.	

Table 5.10 Summary of pH and EC Recorded Over 2023 – Lemington South Permian Coal Measures

Bore C130(WDH) is located between Lemington South pit and the LUG Bore and intersects the Woodlands Hill Seam at a depth of 22 m. Historical readings since 2000 show regular fluctuations of pH ranging between 6.4 and 7.5 and EC ranging from 18,210 μ S/cm to 21,300 μ S/cm. The 2023 readings for pH (6.5) and EC (20,800 μ S/cm) are considered consistent with historical concentrations.

In 2023, Umwelt undertook a trigger investigation for bore C130(WDH). The investigation noted that the C130 series of bores are 28 years old leading to deterioration of the bores over time which may be influencing water quality results. The investigation recommended undertaking comprehensive water quality analysis of water stored in the Lemington South Pit to determine if there is any seepage to the surrounding groundwater, monitored by the C130 series of bores. If it is determined that there is no connection between the pit and the surrounding groundwater, the change in water quality is likely due to bore deterioration, in which case the C130 series of bores should be replaced (Umwelt, 2023b).

Bore B631(BFS) is located approximately 560 m southwest of Lemington South pit and around 660 m east of LUG Bore. Historical readings since 2000 show regular fluctuations of EC between 9,250 μ S/cm and 15,780 μ S/cm. The 2023 reading of 12,860 μ S/cm is therefore considered consistent with historical concentrations.

Bore D214(BFS) is located approximately 490 m west of Lemington South Pit and around 2.2 km north of LUG Bore. Historical readings since 2000 show regular fluctuations of pH between 5.7 to 7.9. The 2023 reading of 6.2 is therefore considered consistent with historical levels. However, it is noted that the EC reading in the same sampling round is very fresh (113 μ S/cm) and the results are not likely representative of groundwater in the area. Groundwater levels fluctuated over 2023 declining and recovering by 17.9 m between August 2022 and August 2023. The fluctuating groundwater levels were specific to bore D214(BFS) as surrounding bores screened within the Bowfield Seam did not record a similar trend. It is recommended the condition of the bore be investigated.

Bore C122(WDH) is located approximately 1,500 m west of Lemington South Pit and 170 m east of Wollombi Brook. Historical readings since 2000 show regular fluctuations of pH ranging from 6.9 to 8.1. The 2023 reading of 7.8 is therefore considered consistent with historical levels.



Bore B631(WDH) is located approximately 580 m southwest of Lemington South Pit and 650 m east of LUG Bore. Historical readings since 2000 show regular fluctuations of pH ranging from 6.4 to 7.3. The 2023 reading of 6.5 is therefore considered consistent with historical levels.

Bore D010(GM) is located between Lemington South Pit and LUG Bore. Historical readings since 2000 show regular fluctuations of EC between 9,050 μ S/cm and 12,310 μ S/cm. The 2023 reading of 11,470 μ S/cm is therefore considered consistent with historical concentrations.





5.3 Spoil

Two bores in spoil were recorded as blocked in 2023, with bore DM3 recorded as blocked in Q1 and bore GW-108 recorded as blocked in Q1 and Q3. Discussion on groundwater level and quality trends within the spoil is included for each of the mine locations from **Section 5.3.1** to **Section 5.3.2**.

In 2023, AECOM investigated the blockage in GW-108 with a downhole camera. The bore is deformed at depth preventing the collection of water quality samples. It is recommended that alternative sampling methods are trialled and if unsuccessful the bore should be replaced as it forms part of the monitoring programme following void closure.

In addition, comparison of groundwater levels and bore screen interval indicates bore GW-114, located within North Pit, is likely dry, and readings may relate to water within the sump at the base of the bore. Bore GW-107, located within the Carrington area, was recorded as dry over 2023.

5.3.1 North Pit

5.3.1.1 Groundwater Level Trends

Groundwater levels for the spoil are presented in **Figure 5.24**. Over 2023, groundwater levels within the bores ranged between 35.52 mAHD (31.58 mbgl) and 78.96 mAHD (23.77 mbgl), in bores MB14HVO03 and DM1, respectively. Groundwater levels decreased by up to 1.4 m (DM7), consistent with rainfall trends. Groundwater within the spoil flows from northern-most bore DM1 in a southerly direction towards the southern-most bore MB14HVO03.



Figure 5.24 Groundwater Levels – North Pit Spoil



5.3.1.2 Groundwater Quality Trends

The pH and EC readings recorded over 2023 are summarised in Table 5.11.

Screened Lithology	pH Range	EC Range (µS/cm)	Comment
Spoil 6.4 – 8.3 3		3,530 – 11,620	Bores DM1 recorded pH (6.4) below the lower trigger level and bore DM7 recorded pH (8.3) above the upper trigger level in Q1.

Table 5.11Summary of pH and EC Recorded Over 2023 – North Pit Spoil

Bore DM1 is located within North Pit and intersects spoil. Historical pH readings since 2011 range between 6.4 and 6.9. The 2023 reading of 6.4 is therefore considered consistent with historical concentrations.

Bore DM7 is located within North Pit and intersects spoil. Historical pH readings since 2010 range between 6.8 and 8.8. The 2023 reading of 8.3 is therefore considered consistent with historical concentrations.

5.3.2 Carrington

5.3.2.1 Groundwater Level Trends

Groundwater levels for the spoil are presented in **Figure 5.25**. Bore GW-108 was blocked in Q1 and Q3. Groundwater levels recorded in Q2 and Q4 in bore GW-108 ranged between 27.61 mAHD (56.79 mbgl) and 28.32 mAHD (56.08 mbgl). Bore GW-107 was recorded as dry over 2023.

Although not included in the WMP, bore GW-129 has also been reviewed as it monitors groundwater levels within the spoil in the Carrington area to the west of the NV TSF. Over 2023, groundwater levels within GW-129 declined from 59.02 mAHD (13.28 mbgl) to 57.14 mAHD (15.16 mbgl) in response to below average rainfall over the same period.





Figure 5.25 Groundwater Levels – Carrington Spoil

5.3.2.2 Groundwater Quality Trends

Routine monitoring of EC and pH was unable to undertaken at bores GW-107 and GW-108 which were recorded as dry (GW-107) and blocked (GW-108) over 2023. Although not included in the WMP, due to limited data for the Carrington spoil water quality data from bore GW-129 has been reviewed. Over 2023, pH levels ranged from 6.9 to 7.5, while EC concentrations fluctuated throughout the year ranging from 6,550 µS/cm to 9,370 µS/cm.



6.0 Trigger Exceedances

6.1 Groundwater Levels

Groundwater level data collected over 2023 have been compared to the trigger values for the five monitoring bores which have trigger levels assigned as outlined in the WMP (HVO, 2018).

Bores CFW55R, CFW57, CGW53a and CGW55a recorded groundwater level exceedances over 2023. The trigger exceedances have been reviewed by comparing groundwater levels and climate trends as shown in **Figure 5.5** to **Figure 5.9**. An analysis of the trigger exceedance is summarised in **Table 6.2** and location shown on **Figure 6.1**.

It is noted that these water level trigger levels have been superseded with the trigger criteria for NV TSF that were established to monitor performance of measures to minimise seepage to alluvium. The trigger levels have been updated in the revised WMP which is awaiting approval.

6.2 Groundwater Quality

Water quality data collected over 2023 have been compared to the trigger values outlined in the WMP (HVO, 2018). Bores where pH or EC values were outside the trigger level are summarised in **Table 6.1**. However, only bores with three or more consecutive readings outside the trigger level are considered an exceedance. Trigger exceedances have been reviewed by comparing the data to groundwater levels and climate indicated by the cumulative rainfall departure plot. An analysis of the trigger exceedances is summarised in **Table 6.3** and the locations shown on **Figure 6.2**.

Location	WMP Lithology	Bore ID	Monitoring Period	Outside pH Trigger Levels	Above EC Trigger Level
	Interburden	BZ3-1	Q1/Q4	✓	
Convinctor	Alluvium	CGW51a	Q1/Q2/Q3/Q4	\checkmark	
Carrington	Broonie Seam	CGW53	Q1/Q3	✓	
	Alluvium	CGW55a	Q4	✓	
	Alluvium	GW-106	Q3		\checkmark
Carrington West Wing	LBL	CGW45	Q1	✓	
8	Bayswater Seam	CGW46	Q1/Q2/Q4	✓	
	Mt Arthur Seam	BZ2A(1)	Q1	✓	
Chashunt	Mt Arthur Seam	BZ3-3	Q1/Q2/Q3/Q4	✓	
Cheshunt	Mt Arthur Seam	BZ4A(2)	Q1	✓	
	Mt Arthur Seam	CHPZ3D	Q1/Q2	✓	
Chashunt (North Dit	Alluvium	BUNC45A	Q1	✓	
Chesnunt/North Plt	Alluvium	Hobdens Well	Q2/Q3/Q4	\checkmark	

Table 6.1	Summary of Water Quality Readings Outside Trigger Levels Over 2023



Location	WMP Lithology	Bore ID	Monitoring Period	Outside pH Trigger Levels	Above EC Trigger Level
	Bowfield Seam	B631(BFS)	Q4		\checkmark
	Woodlands Hill Seam	B631(WDH)	Q4	~	
	Woodlands Hill Seam	C122(WDH)	Q2	~	
Lemington South	Woodlands Hill Seam	C130(WDH)	Q4	~	\checkmark
	Glen Munro Seam	D010(GM)	Q4		\checkmark
	Bowfield Seam	D214(BFS)	Q2	✓	
	Alluvium	PB01(ALL)	Q4		\checkmark
North Dit	Spoil	DM1	Q1	~	
North Pit	Spoil	DM7	Q1	~	
Mart Dit	Alluvium	GW-100	Q2/Q3/Q4		\checkmark
west Pit	Sandstone/Siltstone	NPz2	Q1/Q2/Q3/Q4		✓



Table 6.2 Groundwater Level Trigger Exceedances

Bore ID	Exceedance	Location	Screened Lithology	Comment	Actions
CFW55 R	Twelve consecutive water level readings above the 95 th percentile trigger level of 59.41 mAHD since April 2022	Carrington Billabong area, 80 m west of NV TSF and ~500 m northeast of the Hunter River	Carrington Alluvium	The purpose of bore CFW55R is monitoring of the groundwater response to mining/recovery in Carrington and the NV TSF. Groundwater levels in bore CFW55R have gradually increased since February 2020 with a sharp increase between September 2021 and September 2022 in response to above average rainfall and is not related to mining activities. Over 2023, groundwater levels declined in response to below average rainfall.	The trigger level within the current WMP has been superseded by triggers developed for monitoring the NV TSF seepage and have been updated in the draft WMP which is with DPHI for approval. The revised triggers were not exceeded over 2023. No further action required.
CFW57	Nineteen consecutive water level readings above the 95 th percentile trigger level of 59.24 mAHD since December 2021	Carrington Billabong area, ~520 m west of NV TSF and ~80 m northeast of the Hunter River	Carrington Alluvium	The purpose of bore CFW57 is monitoring of the groundwater response to mining/recovery in Carrington and the NV TSF. Groundwater levels in bore CFW57 have gradually increased since February 2020 with a sharp increase between September 2021 and September 2022 in response to above average rainfall and is not related to mining activities. Over 2023, groundwater levels declined in response to below average rainfall.	The trigger level within the current WMP has been superseded by triggers developed for monitoring the NV TSF seepage and have been updated in the draft WMP which is with DPHI for approval. The revised triggers were not exceeded over 2023. No further action required.
CGW5 3a	Eleven consecutive water level readings above the 95 th percentile trigger level of 59.19 mAHD since June 2021	Carrington Billabong area, ~1000 m west of NV TSF and ~100 m northeast of the Hunter River	Carrington Alluvium	The purpose of bore CGW53a is monitoring of the groundwater response to mining/recovery in Carrington. Groundwater levels in bore CGW53a have gradually increased since December 2019 with a sharp increase between September 2021 and September 2022 in response to above average rainfall and is not related to mining activities. Over 2023, groundwater levels declined in response to below average rainfall.	The trigger level within the current WMP has been updated in the revised WMP which is with DPHI for approval. The revised trigger was exceeded in March 2023 following above average rainfall in 2022. Groundwater levels had a declining trend below the revised trigger for the remainder of 2023. No further action required.



Bore ID	Exceedance	Location	Screened Lithology	Comment	Actions
CGW5 5a	Nine consecutive water level readings above the 95 th percentile trigger level of 58.43 mAHD since December 2021	Carrington Billabong area, ~850 m west of NV TSF and ~350 m northeast of the Hunter River	Carrington Alluvium	The purpose of bore CGW53a is monitoring of the groundwater response to mining/recovery in Carrington. Groundwater levels in bore CGW53a have gradually increased since December 2019 with a sharp increase between September 2021 and September 2022 in response to above average rainfall and is not related to mining activities. Over 2023, groundwater levels declined in response to below average rainfall.	The trigger level within the current WMP has been updated in the revised WMP which is with DPHI for approval. The revised trigger was exceeded until September 2023 following above average rainfall in 2022; however, levels had a declining trend over 2023. No further action required.



Table 6.3 Groundwater Quality Trigger Exceedances

Bore ID	Exceedance	Location	Screened Lithology	Comment/Trend	Actions
BZ3-3	pH – eleven consecutive readings below the lower pH trigger level of 6.5 since November 2019	Cheshunt	Mt Arthur Seam	Bore BZ3-3, located between Cheshunt Pit and the Hunter River, and had an increasing pH trend between June 2006 (6.0) and August 2012 (7.1) followed by a decreasing trend between December 2012 (7.1) and November 2022 (6.1). The 2023 readings ranging between of 6.2 and 6.4 are within the historical range. The 2019 Groundwater Annual Review (SLR, 2020) recommended further investigation of the bore condition and construction to confirm the geology being monitored in all of the 'BZ' bores in the Cheshunt area to understand the cause of the variability in the trends between the bores. Comprehensive water quality analysis was undertaken in August 2022. The results indicated the declining pH trend is not due to connectivity to spoil water via the nearby fault.	The bore condition should be checked and confirm if the bore is a 50 mm PVC bore and able to be adequately sampled. It is noted that the bore has already been removed from the compliance monitoring network in version 3.4 of the revised WMP which is currently with DPHI for approval.
CGW51a	pH – six consecutive readings above the trigger level of 7.4 since September 2022	Carrington	Interburden	Bore CGW51a is located 500 m to the northwest of the NV TSF and approximately 480 m northeast of the Hunter River and intersects interburden. Historic pH readings range from 6.8 (November 2006) and 8.1 (May 2008). The 2023 readings ranged between 7.7 and 8.3, moving outside of the historic range in December 2023. The 2019 Annual Review (SLR, 2019) noted the bore is screened within alluvium and weathered coal measures. It was recommended the bore be decommissioned and replaced with a new bore as the current bore does not provide representative results from one groundwater unit.	Decommission bore to prevent potential mixing of alluvial and Permian aquifers and install a replacement bore which can be used to assist with future assessments and post closure monitoring. It is noted that the bore has already been removed from the compliance monitoring network in version 3.4 of the revised WMP which is currently with DPHI for approval.
Hobden s Well	pH – three consecutive readings above the trigger level of 7.6 since May 2023	Cheshunt/North Pit	Alluvium	Bore Hobdens Well is located between Cheshunt Pit and the Hunter River and intersects alluvium. Historic pH readings range from 7.1 (September 2007) and 8.2 (June 2005). The 2023 readings ranged between 7.2 and 7.7 and are within the historical range. pH has fluctuated above and below the upper trigger level since monitoring began in 2008. The pH level and trend are similar to nearby bore BZ1-1 which is screened within interburden. MER (2005) also noted	The pH trend is similar to historical trends and is in response to climatic and streamflow changes. Trends should continue to be monitored to determine if they are related to mining activities. Recommend reviewing trigger level to reflect historical trends.


Bore ID	Exceedance	Location	Screened Lithology	Comment/Trend	Actions
				that the Mt Arthur Seam lies directly beneath the alluvium in this area. Groundwater levels declined by over 3 m in response to below average rainfall in 2023. EC fluctuated over 2023 with only a minor increase and then decline of ~200 μ S/cm.	
GW-100	EC – three consecutive readings above the trigger level of 10,751 μS/cm since June 2023	West Pit	Alluvium	Bore GW-100 is located approximately 1.8 km south of Plashett Reservoir and 2.4 km west of West Pit and intersects alluvium. Historic EC readings range from 9,570 μ S/cm (September 2019) and 11,510 μ S/cm (December 2017). The 2023 readings ranged between 10,560 μ S/cm and 11,060 μ S/cm and are within the historical range. An increasing trend in EC has been recorded since December 2022 and coincides with declining groundwater levels in response to below average rainfall.	The EC exceedances are due to declining groundwater levels. Trends should continue to be monitored to determine if they are related to mining activities.
NPz2	EC – six consecutive readings above the trigger level of 13,428 μS/cm between September 2022 and December 2023	West Pit	Sandstone/Sil tstone	Bore NPz2, located approximately 4.5 km northeast of Plashett Reservoir and 1 km northwest of the West Pit mine area, has a screened interval between 57-60 mbgl within interburden underlying coal seams. EC readings range from 12,590 μS/cm (December 2014) and 19,400 μS/cm (December 2009). The 2023 readings ranging between 13,620 μS/cm and 14,410 μS/cm are consistent with historical concentrations. SLR (2020) previously recommended removing NPz2 from the compliance network as the bore location and construction does not provide information on potential impacts related to site activities but should remain in the operational network for future assessments and post closure monitoring.	It is noted that the bore has already been removed from the compliance monitoring network in the updated draft WMP which is currently with DPHI for approval. However, NPz2 should remain in the operational monitoring network to assist with future assessments and post closure monitoring. No further action is required.

FIGURE 6.1

Exceedence

Legend

Boundary

Boundary
Named Waterbody

0

Groundwater Level

Groundwater Level Exceedence

HVO South Development Consent

Groundwater No Exceedence Mapped Watercourses (named) HVO North Development Consent

USERSHHARIRAMUMWELT AUSTRALIA) PTY LTD/21188 - 03 S&VF R15/2188 R15 LEMINGTONSOUTH V3 APRX - 21188 R07 001 GROUNDWATERLEVCEEDENCE V



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FIGURE 6.2

Groundwater Quality Exceedence

Legend

- Exceedance Type
- O EC Exceedance
- pH Exceedance
- Groundwater No Exceedence
 Mapped Watercourses (named)
- HVO North Development Consent Boundary
- HVO South Development Consent Boundary
- Named Waterbody



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7.0 Groundwater Take

The direct or indirect take of all groundwater is required to be accounted for under the Water Management Act 2000. At HVO the take of water occurs via:

- Direct take:
 - o Incidental take water intercepted within mine workings and extracted for safety.
 - Consumptive take water pumped directly from water supply bores (i.e., LUG bore).
- Indirect take depressurisation of Permian coal measures inducing inter-formation flows. Indirect take includes loss of baseflow, reduced upward seepage from Permian to alluvium and additional seepage from alluvium to underlying Permian.

Each activity is discussed below, and the estimated groundwater take for the various water sources summarised in **Section 7.3**.

7.1 Groundwater Inflows to Mine Operations (Incidental and Indirect Take)

A numerical groundwater model was developed for the HVO Continuation Project Groundwater Impact Assessment (AGE, 2022). The model was calibrated up to December 2020 and replicates mine progression on a quarterly basis to the year 2056. Results representing 2023 were extracted from the model representing predicted groundwater conditions and take for the 2023 reporting period for inclusion in this report.

Loss of baseflow is required to be assessed as specified in the WMP. Loss of baseflow includes reduction in contributions to the river from connected alluvium and additional leakage of streamflow into the connected alluvium. Baseflow is not measurable, and therefore can only be quantified and reported on from the groundwater model with results provided as indirect take. This process is illustrated in **Figure 7.2** below.

Baseflow loss from the Hunter River is accounted for in the indirect take under the Hunter Regulated River Water Source WSP (Hunter River management zone). Baseflow loss in Wollombi Brook is accounted for in the indirect take under the Hunter Unregulated River and Alluvial Water Source WSP (Lower Wollombi Brook Water Source management zone). Indirect take, inclusive of baseflow, is reported in **Table 7.1**.

As shown in **Figure 7.2**, the system is connected, and indirect take also includes reduced upward seepage from Permian to alluvium and additional seepage from alluvium to underlying Permian. Therefore, water loss in the alluvium in turn induces water loss from the surface water system. Consistent with the approach undertaken for previous approvals, and as reported by AGE (2016), to exclude double accounting in this connected system the maximum indirect take from any one source (alluvium or surface water) is applied.





Figure 7.1 Schematic Showing Baseflow Licensing (Source: AGE, 2016)

7.2 Bore Abstraction (Consumptive Take)

Lemington Underground (LUG) bore is an abstraction bore constructed into the abandoned LUG mine void underlying HVO. The bore is licensed to take up to 1,800 ML of water from the North Coast Fractured and Porous Rock aquifer (20BL173392) per water year. The bore is equipped with a flow meter, with total monthly abstraction documented. Based on the flow volumes recorded, from July 2022 to June 2023 (water year) 283.7 ML of water was abstracted from the LUG bore, which is within the licensed allocation of 1,800 ML/year. From June 2023 to December 2023 water was abstracted in December totalling 315.8 ML.

As the bore intersects LUG that mined the Permian coal measures, groundwater levels within bores intersecting the coal measures around the bore have been reviewed to identify the extent of groundwater drawdown. As discussed in **Section 5.2.4.1**, groundwater levels within the Bowfield Seam of the Permian coal measures around Lemington South have declined by up to 7.4 m in bores within 1.2 km the LUG Bore, in response to abstraction from LUG Bore over 2023.

LUG Bore groundwater levels and daily abstraction volumes since January February 2018 are shown in **Figure 7.1**.





Figure 7.2 Groundwater Level and Monthly Abstraction Volume – LUG Bore

7.3 Summary of Groundwater Take

The predicted take of groundwater from the various groundwater sources associated with HVO and are summarised in **Table 7.1**. Over the 2023 reporting year the total take under the Hunter Regulated water source was estimated at 27 ML, total take from Hunter Unregulated water source was estimated at 361 ML, and 2,091 ML from the North Coast Fractured and Porous Rock water source.

Groundwater Take	Hunter Regulated River WSP (ML)	Hunter Unregulated River and Alluvial Water Sources WSP (ML)	North Coast Fractured and Porous Rock WSP (ML)
HVO Mine Operations (incidental and indirect take) *	27	361	1,807
LUG Bore Abstraction (consumptive take) ^	-	-	284
Total	27	361	2,091

 Table 7.1
 2023 Predicted Groundwater Take

Note: * HVO Continuation Project (2023).

^ Take over water year (July 2022 to June 2023).



8.0 Summary and Recommendations

8.1 Summary

This annual groundwater review covers data collected from 1 January to 31 December 2023 and was completed in compliance with:

- Condition 27 of Development Consent DA 450-10-2003 for HVO North.
- Condition 28 of the Project Approval PA 06 0261 for HVO South.
- Individual bore license conditions (20BL173587-89, 20BL173847 and 20BL173392).
- Conditions of Environment Protection Licence 640.

Over 2023 operations across HVO included active mining at Cheshunt Pit, Riverview Pit and West Pit, including pre-strip of Wilton and Mitchell Pits. Only one TSF (Carrington Pit TSF) was used during the year on HVO land. Groundwater was abstracted from LUG Bore over 2023.

Review of climate data indicates the region generally experienced below average rainfall over 2023. Similar trends are reflected in stream levels for the Hunter River and Wollombi Brook from the HITS stations and site monitoring locations (WL03, WL05, WL10 and WL14). Stream flows in the Hunter River and Wollombi Brook remained relatively stable over 2023 in response to below average rainfall.

Groundwater monitoring was largely conducted in accordance with the Groundwater Monitoring Programme outlined within the WMP (HVO, 2018). However, water level and water quality readings were not taken in all required bores due to a range of factors such as dry, blocked bore conditions and access restrictions.

Review of groundwater level trends indicates that where saturated, water levels within the alluvium decreased in response to rainfall and stream flow trends following below average rainfall over the reporting period.

Four alluvium bores (CFW55R, CFW57, CGW53a and CGW55a) recorded groundwater level exceedances, attributable to decreased rainfall and streamflow. It is noted that the trigger level for the four alluvium bores has been superseded with triggers developed for monitoring NV TSF seepage and these triggers have either not been exceeded or do not require action in accordance with the trigger response protocol applied. The trigger levels have been revised in the draft WMP which is with DPHI for approval. Groundwater within the Permian coal measures remained relatively stable over 2023.

Review of water quality results and comparison to trigger levels for EC and pH identified that several bores exceeded triggers for EC and pH. However, the 2023 readings were generally in line with historical trends for these bores.



Quantification of groundwater take was undertaken based on reported volumes estimated for approved operations as part of the HVO Continuation Project Groundwater Impact Assessment (AGE, 2022) and metered abstraction volumes from LUG Bore. Based on this, over the 2023 reporting year the total take under the Hunter Regulated water source was estimated at 27 ML, total take from Hunter Unregulated water source was estimated at 361 ML and around 2,091 ML from the North Coast Fractured and Porous Rock water source. These volumes are within the licensed take for each groundwater source.

8.2 Recommendations

Based on review of the available data for 2023, recommendations are summarised in Table 8.1.

Bore ID	Recommendation
4036C	Bore 4036C has been recorded as blocked since December 2022. In 2023, AECOM investigated the condition of the bore with a downhole camera. The casing above the ground had been damaged, but was fixed during the investigation. The bore is blocked with organic matter and was removed; however, it was noted that there was significant sediment build up at the base of the bore and the water column within the bore was dirty. Bore 4036C has been removed from the draft WMP which is awaiting approval. It should also be removed from the monitoring schedule.
4113P	In 2023, AECOM checked the bore with a downhole camera and note the bore has collapsed. The bore has already been removed from the compliance monitoring network in version 3.4 of the revised WMP which is currently with DPHI for approval. It should also be removed from the monitoring schedule.
B425(WD)	The bore was recorded as dry between November 2017 and August 2022. These elevations and trends correspond more closely with trends observed for the Bowfield Seam bores. The bore has already been removed from the compliance monitoring network in version 3.4 of the revised WMP which is currently with DPHI for approval.
BUNC45a	Water levels at or below the base of the screen since monitoring began. Water quality samples should not be collected if water level is below 19.3 mbTOC as they will likely not be representative of the surrounding aquifer.
BZ3-3	Water quality exceedance during the reporting period. Recommend the bore condition be checked and confirm if the bore is a 50 mm PVC bore and able to be adequately sampled. The bore has already been removed from the compliance monitoring network in version 3.4 of the revised WMP which is currently with DPHI for approval.
BZ4A(2)	Recommend that the depth of the base of screen and total depth be verified in the field with a downhole camera and tag line. If current bore details are correct the bore should be removed from the WMP but kept as part of the operational monitoring network for ongoing monitoring of groundwater recovery post mining. Water quality samples should not be collected if the groundwater level is below the base of the screen.
C130(WDH)	Following trigger investigation recommend undertaking comprehensive water quality analysis of water stored in the Lemington South Pit to determine if there is any seepage occurring that is being intercepted by the C130 series of bores. If it is determined that there is no connection between the pit and the surrounding groundwater, the change in water quality is likely due to bore deterioration, in which case the C130 series of bores should be replaced.
CFW55R	Groundwater level trigger exceedance during the reporting period. Revised water level trigger level already updated in version 3.4 of the WMP, which is currently with DPHI for approval.
CFW57	Groundwater level trigger exceedance during the reporting period. Revised water level trigger level already updated in version 3.4 of the WMP, which is currently with DPHI for approval.

Table 8.1 Summary of Recommendations



Bore ID	Recommendation
CGW45	Bore has been blocked and unable to be monitored since 2018. Bore has been checked and an extension has been added to increase the height of the casing above the ground surface to avoid further blockages. Bore blockage checked again in 2023, but blockage unable to be removed. Due to the bore condition CGW45 has been removed from the draft WMP which is awaiting approval. The bore should also be removed from the monitoring schedule.
CGW46	In 2023 AECOM checked the bore with a downhole camera and noted the column of water within the bore was dirty and the screened interval was unable to be seen. The bore was cleaned and purged. It is recommended the condition of the bore is reassessed in the next monitoring round.
CGW51a	Water quality exceedance during the reporting period. Bore CGW51a should be decommissioned to minimise potential mixing due to the construction of the bore. The bore is used to monitor groundwater levels surrounding the backfilled Carrington Pit. Monitoring should continue to ensure the void continues to act as a groundwater sink. To enable this, it is recommended that a new bore be installed to replace CGW51a. The bore has already been removed from the draft WMP which is awaiting approval.
CGW53a	Groundwater level trigger exceedance during the reporting period. Revised water level trigger level already updated in version 3.4 of the WMP, which is currently with DPHI for approval.
CGW55a	Groundwater level trigger exceedance during the reporting period. Revised water level trigger level already updated in version 3.4 of the WMP, which is currently with DPHI for approval.
D214(BFS)	Unique groundwater level fluctuations recorded. Investigate condition of the bore.
D510(AFS)	Bore recorded as blocked in Q4. Check bore condition and remove blockage if possible.
DM3	In 2023, AECOM investigated the blockage with a downhole camera. A number of deformations in the PVC casing were recorded. Recommend adjusting sampling method. If still unable to sample install replacement bore as DM3 forms part of the Final Void Management Plan.
GW-100	Water quality exceedance over the reporting period. The EC exceedances are due to declining groundwater levels. Trends should continue to be monitored to determine if they are related to mining activities.
GW-103	The sensors have been checked and are irreparable. The VWP has been removed from the draft WMP which is awaiting approval. The VWP should also be removed from the monitoring schedule.
GW-105	The deepest sensor (VW3) has failed due to an open circuit and is no longer recording data. The sensor should be removed from the revised WMP and the monitoring schedule.
GW-108	In 2023, AECOM investigated the blockage with a downhole camera. The bore is deformed at depth preventing the collection of water quality samples. It is recommended that alternative sampling methods are trialled and if unsuccessful the bore should be replaced as it forms part of the monitoring programme for void closure.
GW-109	Review local site conditions to determine if any additional source of recharge to the shallow stratigraphy is present. The status of the VW3 sensor should also be reviewed as trends indicate the sensory is possibly failing again.
GW-110	If calibration data from VWP installation remains unavailable to convert raw data to water levels, decommission VWP and remove from monitoring schedule.
Hobdens Well	Water quality exceedance during the reporting period. The pH trend is similar to historical trends and is in response to climatic and streamflow changes. Trends should continue to be monitored to determine if they are related to mining activities. Review trigger level to reflect historical trends.
NPz2	Water quality exceedance during the reporting period. It is noted that the bore has already been removed from the compliance monitoring network in version 3.4 of the WMP which is currently with DPHI for approval. Bore NPz2 should remain in the monitoring program to assist with future assessments and assessment of post closure groundwater conditions.
NPz3	Bore NPz3 has been recorded as blocked since December 2022. In 2023, AECOM investigated the condition of the bore using a downhole camera. The footage showed major deformation of the PVC casing. It is recommended that the bore is replaced as it will be required for monitoring of final voids following closure.



9.0 References

Australasian Groundwater and Environmental Consultants (AGE), 2013a. 2012 HVO South Groundwater Impacts Report, prepared for Coal & Allied Operations Pty Ltd, March 2013.

Australasian Groundwater and Environmental Consultants (AGE), 2013b. HVO North Modification Fine Reject Emplacement Groundwater Assessment, prepared for Coal & Allied Operations Pty Ltd, June 2013.

Australasian Groundwater and Environmental Consultants (AGE), 2016. HVO North Modification 6 Groundwater Study, prepared for EMM Consulting for Coal & Allied Operations Pty Ltd, November 2016.

Australasian Groundwater and Environmental Consultants (AGE), 2017. HVO South Modification 5 Groundwater Study, prepared for EMM Consulting for Coal & Allied Operations Pty Ltd, January 2017.

Australasian Groundwater and Environmental Consultants (AGE), 2022. HVO Continuation Project Groundwater Impact Assessment, prepared for EMM Consulting for Coal & Allied Operations Pty Ltd, December 2022.

Department of Environment and Science (DES), 2022. SILO – Australian Climate Data from 1889 to Yesterday. https://www.longpaddock.qld.gov.au/silo/

Bureau of Meteorology (BoM), 2018. Bureau of Meteorology Groundwater Dependent Ecosystems Atlas. http://www.bom.gov.au/water/groundwater/gde/

EMM Consulting (EMM), 2022. HVO Continuation Project – Water Assessment (Appendix K), Prepared for Hunter Valley Operations Pty Ltd, December 2022, H190408 RP9.

Environmental Resources Management (ERM), 2008. Groundwater Assessment, Hunter Valley Operations South Coal Project, Annex J, prepared for Coal & Allied Operations Pty Ltd, January 2008.

Hunter Valley Operations (HVO), 2018. Hunter Valley Operations – Water Management Plan. Hunter Valley Operations Pty Ltd. Version 3.0, 16 October 2018.

Mackie Environmental Research (MER), 1998. Hunter Valley South Mining Extension: Groundwater and Surface Water Management Studies, prepared for Rio Tinto Coal, July 1998.

Mackie Environmental Research (MER), 2003. West Pit Extension Groundwater Assessment, prepared for Coal & Allied, 2003.

Mackie Environmental Research (MER) 2005. Assessment of River Leakage Within the Cheshunt Pit Buffer Zone, prepared for Coal & Allied, April 2005.

Mackie Environmental Research (MER) 2010. Carrington West Wing Modification – Groundwater Assessment, prepared for Coal & Allied, in Carrington West Wing Environmental Assessment (EA), Volume 2, Appendix E – Groundwater Study, March 2010.

Mackie Martin & Associates, 1992. Hunter Valley Mine Alluvial Floodplain Groundwater Studies, prepared for Coal & Allied, Appendix D – Groundwater Study, August 1992.



SLR Consulting Australia Pty Ltd (SLR), 2019. Hunter Valley Operations – Groundwater Monitoring Network Review. Prepared for Hunter Valley Operations Pty Ltd, July 2019, 620.12182-R12.

SLR Consulting Australia Pty Ltd (SLR), 2020. Hunter Valley Operations – Annual Groundwater Review 2019. Prepared for Hunter Valley Operations Pty Ltd, March 2020. 620.12182.00000-R13.

Umwelt Environmental & Social Consultants (Umwelt), 2023a. North Void Tailings Storage Facility – 2022 Annual Analysis Report. Prepared for Hunter Valley Operations Pty Ltd, February 2023, 21188/R08.

Umwelt Environmental & Social Consultants (Umwelt), 2023b. Water Quality Review – Bores C130(WDH) and C630(BFS). Prepared for Hunter Valley Operations Pty Ltd, July 2023, 21188/R09.

Umwelt Environmental & Social Consultants (Umwelt), 2023c. Triennial Groundwater Model Review – HVO. Prepared for Hunter Valley Operations Pty Ltd, March 2023, 21188/R10.





Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	(Groundwater Monitoring Programme			e
			(m)	Level (mAHD)	(mAHD)	Sensor Depth (mbgl)	Water Level	EC	рН	Comprehensive Analysis	Alk/ Acidity
4032P	Carrington West Wing Alluvium	308609	6402945	69.35	56.89	6.46–12.46	Q	Q	Q	6M	
4034P	Carrington West Wing Alluvium	308239	6402959	71.15	56.86	5.29–14.29	Q	Q	Q	6M	
4036C	Carrington Interburden	308272	6402688	70.7	37.68	32.02-33.02	Q	Q	Q		
4037P	Carrington West Wing Alluvium	308277	6402702	70.74	57.47	7.27–13.27	Q	Q	Q	6M	
4040P	Carrington West Wing Alluvium	308675	6402724	69.16	58.23	4.93–10.93	Q	Q	Q		
4051C	Carrington Interburden	308664	6402721	68.92	37.1	30.82-31.82	Q	Q	Q		
4116P	North Pit Spoil	310681	6400978	70.17	47.98	19.59–22.19	Q	Q	Q	6M	
4119P	North Pit Spoil	312501	6402048	63.51	47.24	13.67–16.27	Q	Q	Q	6M	
Appleyard Farm	Lemington South Alluvium	315491	6394639	53.88	43.88	6.20–9.20	М	Q	Q	А	
B334(BFS)	Lemington South Bowfield	316684	6394088	73.37	9.17	58.20–64.20	Q	6M	6M		
B425(WDH)	Lemington South Woodlands Hill	316010	6395024	57.88	22.69	31.19–35.19	Q	6M	6M	А	
B631(BFS)	Lemington South Bowfield	316425	6394319	72.11	-11.56	77.67–83.67	Q	6M	6M		
B631(WDH)	Lemington South Woodlands Hill	316424	6394319	71.98	39.95	29.53-32.03	6M	6M	6M		
B925(BFS)	Lemington South Bowfield	315921	6394604	62.45	-24.18	80.63-86.63	Q	6M	6M	А	
BC1a	Cheshunt Mt Arthur	312421	6400872	66.08	?	21.70-?	Q	Q	Q		
BUNC45A	Cheshunt / North Pit Alluvium	313667	6402055	72.9	52.9	17.00–20.00	Q	Q	Q	6M	
BUNC45D	Cheshunt Mt Arthur Seam (Piercefield in WMP)	313677	6402060	73.36	44.82	25.54–28.54	Q	Q	Q	6M	
BZ1-1	Cheshunt / North Pit Interburden (Alluvium in WMP)	311472	6400483	71.39	47.79	20.60–23.60	Q	Q	Q	6M	
BZ1-3	Cheshunt Mt Arthur	311472	6400483	71.39	15.79	52.60–55.60	Q	Q	Q	6M	
BZ2A(1)	Cheshunt Mt Arthur	311671	6400561	71.17	19.62	48.55–51.55	Q	Q	Q		
BZ3-1	Cheshunt Interburden	311840	6400640	69.97	?	?	Q	Q	Q		
BZ3-3	Cheshunt Mt Arthur	311840	6400640	69.97	25.83	41.14-44.14	Q	Q	Q		
BZ4A(2)	Cheshunt Mt Arthur	312029	6400705	74.4	34	37.40-40.40	Q	Q	Q		
BZ8-2	Cheshunt Interburden	312685	6401010	67.8	46.8	18.00-21.00	Q	Q	Q	6M	



Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	Groundwater Monitoring Programme				
C122(BFS)	Lemington South Bowfield	315501	6395007	58.2	?	?	Q	Q	Q		
C122(WDH)	Lemington South Woodlands Hill	315501	6395007	58.44	36.13	19.31–22.31	6M	6M	6M		
C130(AFS1)	Lemington South Arrowfield	316400	6394916	63.17	19.56	41.61–43.61	6M	6M	6M	А	
C130(ALL)	Lemington South Interburden	316400	6394916	63.17	46.55	14.62–16.62	Q	Q	Q	А	
C130(BFS)	Lemington South Bowfield	316400	6394916	62.98	-1.18	55.16-64.16	6M	6M	6M		
C130(WDH)	Lemington South Woodlands Hill	316400	6394916	63.14	42.02	18.62–21.12	6M	6M	6M		
C317(BFS)	Lemington South Bowfield	315054	6395007	60.38	-15.76	69.64–76.14	Q	6M	6M		
C317(WDH)	Lemington South Woodlands Hill	315054	6395007	60.12	26.83	30.79–33.29	Q	6M	6M		
C613(BFS)	Lemington South Bowfield	314688	6395243	63.64	-21.05	76.69–84.69	Q	6M	6M		
C621(BFS)	Lemington South Bowfield	315421	6395321	58.37	2.69	46.68–55.68	Q	6M	6M		
C630(BFS)	Lemington South Bowfield	316378	6395306	68.81	20.85	39.96–47.96	6M	6M	6M		
C809(GM/WDH)	Lemington South Woodlands Hill	314207	6395493	59.13	21.44	27.69–37.69	6M	6M	6M		
C919(ALL)	Lemington South Alluvium	315192	6395655	57.94	44.74	7.20–13.20	М	Q	Q	А	
CFW55R	Carrington Alluvium	310439	6402180	69.78	53.88	8.90–15.90	Q	Q	Q	6M	
CFW57	Carrington Alluvium	310084	6402053	70.05	55.35	7.70–14.70	Q	Q	Q	6M	
CGW32	Carrington West Wing Flood Plain	308598	6404872	78.48	56.06	13.42-22.42	Q	Q	Q		
CGW39	Carrington West Wing Flood Plain Alluvium?	308566	6403694	70.31	56.84	4.47–13.47	Q	Q	Q	6M	
CGW45	Carrington West Wing Bayswater Seam (LBL in WMP)	308042	6403349	71.83	?	28.3– ?	Q	Q	Q		
CGW46	Carrington West Wing Bayswater	308413	6403276	71.95	51.80	?	Q	Q	Q	6M	
CGW47a	Carrington West Wing Broonie Seam (Flood Plain in WMP)	308731	6403405	70.39	?	16.03– ?	Q	Q	Q	6M	
CGW49	Carrington West Wing Bayswater Seam (Alluvium in WMP)	308778	6403098	69.05	?	12.78– ?	Q Q Q				
CGW51a	Carrington Interburden	310149	6402419	70.04	54.21	12.83-15.83	Q Q Q				
CGW52	Carrington Broonie	309906	6402255	70.7	28.8	38.90-41.90	Q Q Q				
CGW52a	Carrington Alluvium	309902	6402249	70.61	53.36	14.25–17.25	Q Q Q				
CGW53	Carrington Broonie	309606	6402333	69.87	28.98	37.89–40.89	Q Q Q				



Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	Groundwater Monitoring Programme				
CGW53a	Carrington Alluvium	309606	6402333	69.83	55.83	11.00–14.00	Q	Q	Q		
CGW55a	Carrington Alluvium	309840	6402457	70.56	55.24	12.32–15.32	Q	Q	Q		
CHPZ10A	Cheshunt / North Pit Alluvium	313334	6402297	62.57	50.77	8.70–11.80	Q	Q	Q	6M	
CHPZ12A	Cheshunt / North Pit Alluvium	313238	6402013	63.13	51.93	9.20–11.20	Q	Q	Q	6M	
CHPZ12D	Cheshunt Mt Arthur	313236	6402019	63.26	51.51	? –11.75	Q	Q	Q	6M	
CHPZ1A	Cheshunt / North Pit Alluvium	312820	6401697	65.9	48.2	14.00-17.70	Q	Q	Q	6M*	
CHPZ2A	Cheshunt / North Pit Alluvium	312941	6401539	65.14	48.88	13.06–16.26	Q	Q	Q	6M	
СНРΖЗА	Cheshunt / North Pit Alluvium	313086	6401756	63.18	52.36	13.82-10.82	Q	Q	Q	6M	
CHPZ3D	Cheshunt Mt Arthur	313094	6401756	62.96	40	19.86–22.96	Q	Q	Q	6M	
CHPZ4A	Cheshunt / North Pit Alluvium	312904	6402123	65.45	51.99	10.16-13.46	Q	Q	Q	6M	
CHPZ8A	Cheshunt / North Pit Alluvium	313503	6402051	60.05	54.85	3.20-5.20	Q	Q	Q	6M	
CHPZ8D	Cheshunt Mt Arthur	313508	6402047	59.89	51.6	4.79–8.29	Q	Q	Q	6M	
D010(BFS)	Lemington South Bowfield	314355	6395687	55.94	-10.17	59.61–66.11	6M	6M	6M		
D010(GM)	Lemington South Glen Munro	314355	6395687	55.95	39.26	12.19–16.69	6M	6M	6M	А	
D010(WDH)	Lemington South Woodlands Hill	314355	6395687	55.93	33.76	19.17–22.17	6M	6M	6M		
D214(BFS)	Lemington South Bowfield	314768	6395831	56.67	4.5	42.67–52.17	Q	6*M	6*M		
D317(BFS)	Lemington South Bowfield	315043	6396019	59.64	15.77	38.67–43.87	Q	6M	6M		
D406(AFS)	Lemington South Arrowfield	313931	6396074	57.41	30.23	23.68–27.18	6M	6M	6M		
D406(BFS)	Lemington South Bowfield	313931	6396074	57.36	0.68	50.68–56.68	6M	6M	6M		
D510(AFS)	Lemington South Arrowfield	314380	6396141	54.99	24.81	25.18-30.18	6M	6M	6M		
D510(BFS)	Lemington South Bowfield	314380	6396141	54.98	17.28	33.70–37.70	6M	6M	6M		
D612(AFS)	Lemington South Arrowfield	314524	6396314	62.16	?	23.62-?	6M 6M		6M		
D612(BFS)	Lemington South Bowfield	314524	6396314	62.1	?	28.81-?	6M 6M 6N		6M		
D807(BFS)	Lemington South Bowfield	314002	6396484	59.94	19.29	35.65-40.65	6M 6M 6M				
DM1	North Pit Spoil	311778	6405164	102.73	?	28.83- ?	Q	Q	Q	А	Q
DM3	North Pit Spoil	311971	6403310	94.14	?	40.67-?	Q	Q	Q	А	Q



Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	Groundwater Monitoring Programme				
DM4	North Pit Spoil	312222	6401418	64.85	?	54.16-?	Q	Q	Q	А	Q
DM7	North Pit Spoil	311136	6400961	69.26	?	30.87– ?	Q	Q	Q	А	Q
G1	West Pit Alluvium	305694	6407301	110	?	<10.00-?	Q	Q	Q	А	
G2	West Pit Alluvium	305660	6407451	110.6	?	3.04-?	Q	Q	q	А	
G3	West Pit Alluvium	305636	6407556	108.6	?	<10.00-?	Q	Q	q	А	
GA3	Cheshunt / North Pit Coal (Alluvium in WMP)	310159	6400876	67.02	?	12.00-?	Q	Q	q		
GW-100	West Pit Alluvium	303729	6406436	89.6	84.6	4.40-5.00	Q	Q	Q	А	
GW-100a (VWP)	Carrington Barrett Seam and Interburden	303722	6406445	89.4	-	51.00	Q*				
GW-101	West Pit Alluvium	304374	6406728	100.5	88.5	9.00-12.00	Q	Q	Q	А	
GW-101a (VWP)	Carrington Interburden (Siltstone/Sandstone)	304362	6406721	100.5	-	51.00	Q*				
GW-102 (VWP)	Carrington Interburden (Sandstone with minor coal)	305280	6406668	114.6	-	60.50	Q*				
GW-103 (VWP)	Carrington Coal – undifferentiated and weathered	306769	6404610	103.2	-	25.50	Q*				
	Carrington Siltstone and coal				-	64.50					
	Carrington Sandstone – mg, fresh				-	119.50					
GW-104 (VWP)	Carrington Lower Pikes Gully Seam	307549	6404657	86.7	-	59.00	Q*				
	Carrington Sandstone IB (near Upper Liddell Seam)				-	107.00					
	Carrington Sandstone (above Barret)				-	135.00					
GW-105 (VWP)	Carrington Coal – undifferentiated	308597	6405442	93.1	-	33.00	Q*				
	Carrington Coal – tuffaceous				-	103.50					
	Carrington Coal				-	154.00					
GW-106	Carrington West Wing Alluvium	309092	6405224	82.3	56.1	23.20–26.20	Q	Q	Q	А	
GW-107	Carrington Spoil	308738	6404103	73.5	46.3	24.20–27.20	Q	Q	Q	А	
GW-108	Carrington Spoil	309695	6403971	84.4	25.9	52.50–58.50	Q	Q	Q	А	
GW-109 (VWP)	Carrington Coal – slightly weathered	309232	6402706	85.2	-	31.50	Q*				
	Carrington Coal – tuffaceous				-	65.00					
	Carrington Bayswater Seam				-	89.50					



Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	Groundwater Monitoring Programme				
GW-110 (VWP)	Carrington Sandstone – fresh	310503	6404598	124.6	-	38.00	Q*				
	Carrington Sandstone				-	63.00					
	Carrington Bayswater Seam				-	93.00					
GW-114	North Pit Spoil	312272	6403981	98.2	68.2	27.00–30.00	Q	Q	Q	A	
GW-115	North Pit Spoil	312227	6402216	68.3	40.1	22.20–28.20	Q	Q	Q	А	
HG2	Cheshunt Interburden	312469	6400886	67.4	51.03	10.37–16.37	Q	Q	q		
HG2a	Cheshunt Mt Arthur	312469	6400886	66.82	39.07	25.75–27.75	Q	Q	Q		
Hobdens Well	Cheshunt / North Pit Alluvium	312540	6401093	71	?	?	Q	Q	Q	А	
HV3(2)	Cheshunt / North Pit Alluvium	310776	6400546	68.06	51.94	? –16.12	Q	Q	q		
LUG Bore	Lemington South Mt Arthur	315874	6394295	?	?	?	М	Q	Q	А	
MB14HVO01	North Pit Spoil	310587	6401003	71.3	-18.7	? –90.00	Q	Q	Q	А	
MB14HVO02	North Pit Spoil	310469	6401001	70.9	61.9	? –90.00	Q	Q	Q	А	
MB14HVO03	North Pit Spoil	311387	6400950	67.1	-12.9	? –80.00	Q	Q	Q	А	
MB14HVO04	North Pit Spoil	311491	6401392	67.1	12.1	? –55.00	Q	Q	Q	А	
MB14HVO05	North Pit Spoil	310675	6401127	71.7	-13.3	? –85.00	Q	Q	Q	А	
NPz2	West Pit Sandstone/Siltstone	307800	6411340	190.48	131.08	56.40–59.40	Q	Q	Q	А	
NPz3	West Pit Sandstone/Siltstone	306305	6409131	148.4	?	93.30–96.60	Q	Q	Q	А	
NPz5	West Pit Sandstone/Siltstone	310730	6406550	113.76	71.49	39.27–42.27	Q	Q	Q	А	
PB01(ALL)	Lemington South Alluvium	314754	6396026	54.37	42.11	9.26–12.26	М	Q	Q	А	
PZ1CH200	Cheshunt / North Pit Alluvium	312646	6402256	62.06	51.06	>8.90-11.00	Q	Q	Q		
PZ2CH400	Cheshunt / North Pit Alluvium	312635	6402051	62.53	51.43	>9.90-11.10	Q	Q	Q	6M*	
PZ3CH800	Cheshunt / North Pit Alluvium	312522	6401674	64.16	?	10.47-?	Q	Q	Q	6M*	
PZ4CH1380	Cheshunt / North Pit Alluvium	312196	6401176	64.93	?	14.48-?	Q	Q	Q		
PZ5CH1800	Cheshunt / North Pit Alluvium	311852	6400928	66.1	?	14.90- ?	Q	Q	Q		
SR001	Southern Coal	319146	6394094	58.44	?	59.18-?	6M	6M	6M		
SR002	Southern Bayswater Seam	319079	6394620	56.99	16.38	37.61–40.61	6M	6M	6M		



Bore ID	WMP Geology	Easting (m)	Northing	Ground	Screen Base	Screened Interval /	(Groundv	vater Mo	nitoring Programme	9
SR003	Southern Bayswater Seam	318863	6394864	61.33	?	63.88– ?	6M	6M	6M		
SR004	Southern Bayswater Seam	318994	6395506	78.15	?	39.87– ?	6M	6M	6M		
SR005	Southern Bayswater Seam	318831	6396128	65.36	?	26.39– ?	6M	6M	6M		
SR006	Southern Bayswater Seam	318555	6395732	83.31	?	91.44- ?	6M 6M 6M				
SR007	Southern Overburden and Vaux Seam	318772	6394373	60.9	23.4	31.50–37.50	6M	6M	6M	А	
SR008	Southern Siltstone/sandstone below Lemington Seam	319290	6395111	56.8	26.4	24.40-30.40	6M	6M	6M	А	
SR009	Southern Lemington Seam	319338	6394746	56.1	19.7	30.40-36.40	6M	6M	6M	А	
SR010	Southern Conglomerate and Warkworth Seam	317319	6395338	57.5	26.9	24.60-30.60	6M	6M	6M	А	
SR011	Southern Mt Arthur Seam and underburden	317699	6394412	88.2	40.8	41.40-47.40	6M 6M 6M			А	
SR012	Southern Overburden – conglomerate and sandstone	316354	6393926	76.2	46.8	23.40-29.40	6M 6M 6M A			A	

Comprehensive analysis includes major ions TDS, Al, As, B, Ca, Cd, Cl, (CO3), Cu, Hg, K, Mg, Na, Ni, Pb, Se, SO4 (or S), Zn, Total Alkalinity, Bicarbonate Alkalinity, Carbonate Alkalinity, Hydroxide Alkalinity.

*TDS, Al, As, B, Be, Ca, Cd, Cl, CO3, Co, Cu, F, Fe, Hg, K, Mg, Mn, Na, Ni, NH3, NO2, NO3, P, Pb, Rb, Sb, Se, SO4 (or S), SiO2, Sr, Zn, Total Alkalinity, Bicarbonate Alkalinity, Carbonate Alkalinity, Hydroxide Alkalinity.

Notes: Q* – Data downloaded quarterly

M – Monthly

Q – Quarterly

6M – Six Monthly

A – Annual



Table B.1 Groundwater Level Data – Alluvium

Poro ID	WMR Goology	Ground Level	Screen Base	Screened	(Q1 SWL (mAHD)		Q2 SWL (mAHD))	(Q3 SWL (mAHD)		Q4 SWL (mAHD)
Bore ib	WWF Geology	(mAHD)	(mAHD)	(mbgl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4032P	Carrington West Wing Alluvium	69.35	56.89	6.46 - 12.46	-	-	61.53	-	-	61.15	-	-	60.74	-	-	60.58
4034P	Carrington West Wing Alluvium	71.15	56.86	5.29 - 14.29	-	-	61.01	-	-	60.52	-	-	60.16	-	-	59.93
4037P	Carrington West Wing Alluvium	70.74	57.47	7.27 - 13.27	-	-	61.65	-	-	61.23	-	-	60.88	-	-	60.64
4040P	Carrington West Wing Alluvium	69.16	58.23	4.93 - 10.93	-	-	61.24	-	-	60.88	-	-	60.61	-	-	60.40
CGW49	Carrington West Wing Alluvium	69.05	?	12.78 - ?	-	-	61.53	-	-	61.11	-	-	60.80	-	-	60.58
GW-106	Carrington West Wing Alluvium	82.30	56.10	23.20 - 26.20	-	-	59.67	-	-	59.66	-	-	59.68	-	-	59.65
CGW32	Carrington West Wing Flood Plain	78.48	56.06	13.42 - 22.42	-	-	59.56	-	-	59.53	-	-	59.54	-	-	59.52
CGW39	Carrington West Wing Flood Plain	70.31	56.84	4.47 - 13.47	-	-	60.69	-	-	60.42	-	-	60.17	-	-	59.99
CGW47a	Carrington West Wing Flood Plain	70.39	?	16.03 - ?	-	-	61.48	-	-	61.14	-	-	60.80	-	-	60.57
CFW55R	Carrington Alluvium	69.78	53.88	8.90 - 15.90	60.07	59.91	59.78	-	-	59.54	59.41	59.37	59.08	59.23	59.17	59.08
CFW57	Carrington Alluvium	70.05	55.35	7.70 - 14.70	60.27	60.09	59.93	-	-	59.72	59.59	59.53	58.97	59.36	59.32	59.22
CGW51a	Carrington Alluvium	70.04	54.21	12.83 - 15.83	-	-	58.69	-	-	58.37	-	-	57.85	-	-	57.47
CGW52a	Carrington Alluvium	70.61	53.36	14.25 - 17.25	-	-	60.19	-	-	59.80	-	-	59.56	-	-	59.33
CGW53a	Carrington Alluvium	69.83	55.83	11.00 - 14.00	-	-	60.26	-	-	59.87	-	-	59.58	-	-	59.37
CGW55a	Carrington Alluvium	70.56	55.24	12.32 - 15.32	-	-	61.63	-	-	59.58	-	-	59.24	-	-	58.74
BUNC45A	Cheshunt / North Pit Alluvium	72.90	52.90	17.00 - 20.00	-	-	53.52	-	53.30	-	53.25	-	52.98	52.85	52.83	52.73
BZ1-1	Cheshunt / North Pit Alluvium	71.39	47.79	20.60 - 23.60	-	-	54.13	-	53.84	-	-	53.71	53.67	53.58	53.59	53.50
CHPZ10A	Cheshunt / North Pit Alluvium	62.57	50.77	8.70 - 11.80	-	-	55.51	-	54.98	-	54.77	54.67	54.51	54.43	54.39	54.31
CHPZ12A	Cheshunt / North Pit Alluvium	63.13	51.93	9.20 - 11.20	-	-	55.73	-	55.18	-	54.96	54.85	54.69	54.61	54.56	54.46
CHPZ1A	Cheshunt / North Pit Alluvium	65.90	48.20	14.00 - 17.70	-	-	56.83	-	56.28	-	56.09	55.97	55.83	55.74	55.70	55.62
CHPZ2A	Cheshunt / North Pit Alluvium	65.14	48.88	13.06 - 16.26	-	-	55.85	-	55.32	-	55.15	55.04	54.91	54.83	54.78	54.68
CHPZ3A	Cheshunt / North Pit Alluvium	63.18	52.36	13.82 - 10.82	-	-	55.83	-	55.29	-	55.06	54.95	54.80	54.71	54.67	54.55
CHPZ4A	Cheshunt / North Pit Alluvium	65.45	51.99	10.16 - 13.46	-	-	55.69	-	55.17	-	63.80	54.88	54.72	54.65	54.60	54.50
CHPZ8A	Cheshunt / North Pit Alluvium	60.05	54.85	3.20 - 5.20	-	-	55.73	-	55.15	-	54.89	54.77	54.61	54.51	54.47	54.35
GA3	Cheshunt / North Pit Alluvium	67.02	?	12.00 - ?	-	-	57.29	-	57.47	-	57.07	57.39	57.30	56.82	56.78	56.73
Hobdens Well	Cheshunt / North Pit Alluvium	71.00	?	?	-	-	60.36	-	59.93	-	59.86	59.78	59.64	59.56	59.53	59.43
HV3(2)	Cheshunt / North Pit Alluvium	68.06	51.94	? - 16.12	-	-	58.12	-	58.04	-	58.05	57.93	57.90	57.85	57.84	57.70
PZ1CH200	Cheshunt / North Pit Alluvium	62.06	51.06	>8.90 - 11.00	-	-	No Access	-	No Access	-	55.04	54.93	54.89	54.80	54.82	54.71
PZ2CH400	Cheshunt / North Pit Alluvium	62.53	51.43	>9.90 - 11.10	-	-	54.35	-	No Access	-	54.01	-	53.85	53.77	53.76	53.69
PZ3CH800	Cheshunt / North Pit Alluvium	64.16	?	10.47 - ?	-	-	55.25	-	No Access	-	55.10	-	54.94	54.86	54.85	54.77
PZ4CH1380	Cheshunt / North Pit Alluvium	64.93	?	14.48 - ?	-	-	55.66	-	No Access	-	55.47	55.30	55.19	55.15	55.14	55.04
PZ5CH1800	Cheshunt / North Pit Alluvium	66.10	?	14.90 - ?	-	-	55.95	-	No Access	-	55.79	55.66	55.56	55.44	55.42	55.34
Appleyard Farm	Lemington South Alluvium	53.88	43.88	6.20 - 9.20	48.58	48.74	48.44	48.47	48.44	48.39	48.37	48.31	48.23	48.16	48.11	48.01
C919(ALL)	Lemington South Alluvium	57.94	44.74	7.20 - 13.20	49.92	49.85	49.82	49.66	49.63	49.64	49.45	49.45	49.27	49.20	49.13	49.07
PB01(ALL)	Lemington South Alluvium	54.37	42.11	9.26 - 12.26	47.26	47.02	46.95	46.90	46.87	46.80	46.71	46.69	46.62	46.58	46.55	46.37
G1	West Pit Alluvium	110.00	?	<10.00 - ?	-	108.42	108.57	-	-	108.42	-	-	108.64	-	-	108.02
G2	West Pit Alluvium	110.60	?	3.04 - ?	109.25	109.55	109.69	-	-	109.44	-	-	109.65	-	-	109.00
G3	West Pit Alluvium	108.60	?	<10.00 - ?	106.74	107.11	107.30	-	-	107.17	-	-	107.29	-	-	106.63
GW-100	West Pit Alluvium	89.60	84.60	4.40 - 5.00	-	-	85.58	-	-	85.52	-	-	85.50	-	-	85.08
GW-101	West Pit Alluvium	100.50	88.50	9.00 - 12.00	-	-	Dry	-	-	Dry	-	-	Dry	-	-	Dry

Table B.2 Groundwater Level Data – Permian Coal Measures

Reve ID	WAR Coolers	Ground Level	Screen Base	Screened		Q1 SWL (mAHD)	(Q2 SWL (mAHD)		Q3 SWL (mAHD)	(Q4 SWL (mAHD)
Bore ID	WWP Geology	(mAHD)	(mAHD)	(mbgl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CGW45	Carrington West Wing LBL	71.83	?	28.3 - ?	-	-	Blocked	-	-	69.47	-	-	Blocked	-	-	Blocked
CGW46	Carrington West Wing Bayswater	71.95	51.80	?	-	-	60.63	-	-	60.27	-	-	59.91	-	-	59.67
CGW52	Carrington Broonie	70.70	28.80	38.90 - 41.90	-	-	37.37	-	-	37.70	-	-	38.38	-	-	38.46
CGW53	Carrington Broonie	69.87	28.98	37.89 - 40.89	-	-	35.82	-	-	36.08	-	-	36.83	-	-	37.02
4036C	Carrington Interburden	70.70	37.68	32.02 - 33.02	-	-	Blocked	-	-	Blocked	-	-	Blocked	-	-	40.64
4051C	Carrington Interburden	68.92	37.10	30.82 - 31.82	-	-	57.79	-	-	57.48	-	-	57.31	-	-	56.97
CGW51a	Carrington Interburden	70.04	54.21	12.83 - 15.83	-	-	58.69	-	-	58.37	-	-	57.85	-	-	57.47
BZ3-1	Cheshunt Interburden	69.97	?	?	-	-	Dry	-	Dry	-	53.73	53.60	53.59	53.49	53.52	53.40
BZ8-2	Cheshunt Interburden	67.80	46.80	18.00 - 21.00	-	-	Bore Collapsed	-	No Access	-	-	-	Dry	Dry	-	Dry
HG2	Cheshunt Interburden	67.40	51.03	10.37 - 16.37	-	-	56.90	-	56.54	-	56.42	56.29	56.19	56.11	56.08	55.98
BC1a	Cheshunt Mt Arthur	66.08	?	21.70 - ?	-	-	49.03	-	48.98	-	49.02	48.96	48.96	48.95	48.97	48.97
BZ1-3	Cheshunt Mt Arthur	71.39	15.79	52.60 - 55.60	-	-	25.29	-	25.25	-	-	25.25	-	-	25.24	-
BZ2A(1)	Cheshunt Mt Arthur	71.17	19.62	48.55 - 51.55	-	-	25.66	-	25.51	-	25.50	25.44	25.41	25.40	25.41	25.39
BZ3-3	Cheshunt Mt Arthur	69.97	25.83	41.14 - 44.14	-	-	28.50	-	28.40	-	-	28.41	-	-	28.39	-
BZ4A(2)	Cheshunt Mt Arthur	74.40	34.00	37.40 - 40.40	-	-	33.72	-	33.61	-	33.68	33.64	33.67	33.70	33.72	33.68
CHPZ12D	Cheshunt Mt Arthur	63.26	51.51	? - 11.75	-	-	55.61	-	55.04	-	54.80	54.72	54.60	54.50	54.43	54.35
CHPZ3D	Cheshunt Mt Arthur	62.96	40.00	19.86 - 22.96	-	-	54.64	-	54.20	-	54.08	54.46	53.84	53.76	53.72	53.62
CHPZ8D	Cheshunt Mt Arthur	59.89	51.60	4.79 - 8.29	-	-	55.79	-	55.31	-	54.96	54.85	54.60	54.64	54.49	54.40
HG2a	Cheshunt Mt Arthur	66.82	39.07	25.75 - 27.75	-	-	41.58	-	41.63	-	-	41.52	-	-	41.49	-
BUNC45D	Cheshunt Piercefield	73.36	44.82	25.54 - 28.54	-	-	48.89	-	48.54	-	48.59	-	48.44	48.39	48.49	48.54
C130(AFS1)	Lemington South Arrowfield	63.17	19.56	41.61 - 43.61		NR (6M)		-	45.29	-		NR (6M)		-	45.21	-
D406(AFS)	Lemington South Arrowfield	57.41	30.23	23.68 - 27.18		NR (6M)		-	38.25	-		NR (6M)		-	36.44	-
D510(AFS)	Lemington South Arrowfield	54.99	24.81	25.18 - 30.18		NR (6M)		-	Dry	-		NR (6M)		-	Blocked	-
D612(AFS)	Lemington South Arrowfield	62.16	?	23.62 - ?		NR (6M)		-	Dry	-		NR (6M)		-	38.73	-
B334(BFS)	Lemington South Bowfield	73.37	9.17	58.20 - 64.20	-	19.45	-	-	19.10	-	-	19.13	-	-	19.02	-
B631(BFS)	Lemington South Bowfield	72.11	-11.56	77.67 - 83.67	-	27.65	-	-	26.47	-	-	25.40	-	-	24.22	-
B925(BFS)	Lemington South Bowfield	62.45	-24.18	80.63 - 86.63	-	6.74	-	-	5.54	-	-	4.23	-	-	2.80	-
C122(BFS)	Lemington South Bowfield	58.20	?	?	-	-0.37	-	-	-0.23	-	-	-0.23	-	-	-0.22	-
C130(BFS)	Lemington South Bowfield	62.98	-1.18	55.16 - 64.16	-	13.98	-	-	13.03	-		NR (6M)		-	10.23	-
C317(BFS)	Lemington South Bowfield	60.38	-15.76	69.64 - 76.14	-	12.70	-	-	11.42	-	-	9.48	-	-	7.82	-
C613(BFS)	Lemington South Bowfield	63.64	-21.05	76.69 - 84.69	-	41.91	-	-	41.78	-	-	41.56	-	-	41.26	-
C621(BFS)	Lemington South Bowfield	58.37	2.69	46.68 - 55.68	-	15.37	-	-	15.64	-	-	15.01	-	-	14.34	-
C630(BFS)	Lemington South Bowfield	68.81	20.85	39.96 - 47.96		NR (6M)		-	23.64	-		NR (6M)		-	24.04	-
D010(BFS)	Lemington South Bowfield	55.94	-10.17	59.61 - 66.11		NR (6M)		-	28.97	-		NR (6M)		-	30.24	-
D214(BFS)	Lemington South Bowfield	56.67	4.50	42.67 - 52.17	-	32.79	-	-	14.89	-	-	32.69	-	-	32.83	-
D317(BFS)	Lemington South Bowfield	59.64	15.77	38.67 - 43.87	-	31.87	-	-	31.96	-	-	32.01	-	-	31.92	-
D406(BFS)	Lemington South Bowfield	57.36	0.68	50.68 - 56.68		NR (6M)		-	22.27	-		NR (6M)		-	19.67	-
D510(BFS)	Lemington South Bowfield	54.98	17.28	33.70 - 37.70		NR (6M)		-	28.25	-		NR (6M)		-	26.94	-
D612(BFS)	Lemington South Bowfield	62.10	?	28.81 - ?		NR (6M)		-	29.23	-		NR (6M)		-	28.73	-
D807(BFS)	Lemington South Bowfield	59.94	19.29	35.65 - 40.65		NR (6M)		-	20.51	-		NR (6M)		-	20.60	-
D010(GM)	Lemington South Glen Munro	55.95	39.26	12.19 - 16.69		NR (6M)		-	50.13	-		NR (6M)		-	49.29	-
C130(ALL)	Lemington South Interburden	63.17	46.55	14.62 - 16.62	47.42	47.44	-	-	47.37	-	-	47.40	-	-	47.39	-
B425(WDH)	Lemington South Woodlands Hill	57.88	22.69	31.19 - 35.19	-	26.05	-	-	23.46	-	-	25.54	-	-	25.64	-
B631(WDH)	Lemington South Woodlands Hill	71.98	39.95	29.53 - 32.03		NR (6M)		-	46.05	-		NR (6M)		-	44.06	-
C122(WDH)	Lemington South Woodlands Hill	58.44	36.13	19.31 - 22.31		NR (6M)		-	47.23	-		NR (6M)		-	47.01	-
C130(WDH)	Lemington South Woodlands Hill	63.14	42.02	18.62 - 21.12		NR (6M)		-	47.23	-		NR (6M)		-	47.25	-
C317(WDH)	Lemington South Woodlands Hill	60.12	26.83	30.79 - 33.29	-	48.19	-	-	47.72	-	-	47.17	-	-	46.68	-
C809(GM/WDH)	Lemington South Woodlands Hill	59.13	21.44	27.69 - 37.69		NR (6M)		-	49.24	-		NR (6M)		-	48.50	-
D010(WDH)	Lemington South Woodlands Hill	55.93	33.76	19.17 - 22.17		NR (6M)		-	47.89	-		NR (6M)		-	47.14	-

Table B.2 Groundwater Level Data – Permian Coal Measures

Bore ID	WIMP Goology	Ground Level	Screen Base	Screened		Q1 SWL (mAHD))	1	Q2 SWL (mAHD)		Q3 SWL (mAHD)	(Q4 SWL (mAHD)
Bore ib	WWF Geology	(mAHD)	(mAHD)	(mbgl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LUG Bore	Lemington South Mt Arthur	?	?	?	NM	(Bore Head Sea	led)	NM	I (Bore Head Sea	iled)	NM	(Bore Head Sea	aled)	NM	(Bore Head Sea	led)
NPz2	West Pit Sandstone/Siltstone	190.48	131.08	56.40 - 59.40	-	-	157.61	-	-	156.81	-	-	158.06	-	-	153.35
NPz3	West Pit Sandstone/Siltstone	148.40	?	93.30 - 96.60		Blocked		-	-	Blocked	-	-	Blocked	-	-	Blocked
NPz5	West Pit Sandstone/Siltstone	113.76	71.49	39.27 - 42.27		Mined through			Mined through	l.		Mined through	l		Mined through	
SR001	Southern Coal	58.44	?	59.18 - ?		NR (6M)		-	-	48.94		NR (6M)		-	-	48.35
SR002	Southern Bayswater Seam	56.99	16.38	37.61 - 40.61		NR (6M)		-	-	43.17		NR (6M)		-	-	42.38
SR003	Southern Bayswater Seam	61.33	?	63.88 - ?	NR (6M) -				-	43.23		NR (6M)		-	-	42.90
SR004	Southern Bayswater Seam	78.15	?	39.87 - ?		NR (6M)		-	-	43.21		NR (6M)		-	-	42.91
SR005	Southern Bayswater Seam	65.36	?	26.39 - ?	NR (6M)				-	44.31		NR (6M)		-	-	43.95
SR006	Southern Bayswater Seam	83.31	?	91.44 - ?		NR (6M)		-	-	44.21		NR (6M)		-	-	43.88
SR007	Southern Overburden and Vaux Seam	60.90	23.40	31.50 - 37.50		NR (6M)		-	-	27.04		NR (6M)		-	-	26.61
SR008	Southern Siltstone/sandstone below Lemington Seam	56.80	26.40	24.40 - 30.40		NR (6M)		-	-	48.04		NR (6M)		-	-	47.93
SR009	Southern Lemington Seam	56.10	19.70	30.40 - 36.40		NR (6M)		-	-	50.05		NR (6M)		-	-	49.91
SR010	Southern Conglomerate and Warkworth Seam	57.50	26.90	24.60 - 30.60		NR (6M)		-	-	47.45		NR (6M)		-	-	47.36
SR011	Southern Mt Arthur Seam and underburden	88.20	40.80	41.40 - 47.40	0 NR (6M)				-	53.78		NR (6M)		-	-	53.95
SR012	Southern Overburden - conglomerate and sandstone	76.20	46.80	23.40 - 29.40	.40 NR (6M)				-	51.66		NR (6M)		-	-	51.53

nr (6m) = not required (6 monthly monitoring only)

Table B.3 Groundwater Level Data – Spoil

Poro ID	W/MR Goology	Ground Level	Screen Base	Intorval	(Q1 SWL (mAHD)		Q2 SWL (mAHD)		Q3 SWL (mAHD)	(Q4 SWL (mAHD)
Bore ID	WINF Geology	(mAHD)	(mAHD)	(mbgl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GW-107	Carrington Spoil	73.50	46.30	24.20 - 27.20	-	-	Dry	-	-	Dry	-	-	Dry	-	-	Dry
GW-108	Carrington Spoil	84.40	25.90	52.50 - 58.50	-	-	Blocked	-	-	27.61	-	-	Blocked	-	-	28.32
4116P	North Pit Spoil	70.17	47.98	19.59 - 22.19	-	-	49.41	-	49.41	-	49.31	-	-	49.22	-	-
4119P	North Pit Spoil	63.51	47.24	13.67 - 16.27	-	-	57.36	-	57.09	-	56.69	-	-	56.22	-	-
DM1	North Pit Spoil	102.73	?	28.83 - ?	-	-	78.96	-	78.83	-	78.74	-	-	78.63	-	-
DM3	North Pit Spoil	94.14	?	40.67 - ?	-	-	Blocked	-	65.52	-	65.57	-	-	65.69	-	-
DM4	North Pit Spoil	64.85	?	54.16 - ?	-	-	50.77	-	50.56	-	50.19	-	-	49.87	-	-
DM7	North Pit Spoil	69.26	?	30.87 - ?	-	-	40.57	-	40.28	-	39.74	-	-	39.13	-	-
GW-114	North Pit Spoil	98.20	68.20	27.00 - 30.00	-	-	67.30	-	67.27	-	67.22	-	-	67.14	-	-
GW-115	North Pit Spoil	68.30	40.10	22.20 - 28.20	-	-	57.35	-	57.13	-	56.77	-	-	56.33	-	-
MB14HVO01	North Pit Spoil	71.30	-18.70	? - 90.00	-	-	40.47	-	40.15	-	39.63	-	-	39.10	-	-
MB14HVO02	North Pit Spoil	70.90	-19.10	? - 90.00	-	-	40.43	-	40.11	-	39.56	-	-	39.05	-	-
MB14HVO03	North Pit Spoil	67.10	-12.90	? - 80.00	-	-	36.65	-	36.37	-	36.09	-	-	35.52	-	-
MB14HVO04	North Pit Spoil	67.10	12.10	? - 55.00	-	-	41.76	-	41.51	-	41.12	-	-	40.69	-	-
MB14HVO05	North Pit Spoil	71.70	-13.30	? - 85.00	-	-	40.63	-	40.30	-	39.78	-	-	39.26	-	-























































500

0

-500

-1000

-1500

-2000

-2500

-3000

500

-500

-1000

-1500

-2000

-2500

-3000

- C130(WDH)

CRD (SILO)

120.24

Cumulative Rainfall Departure (mm)

120.24

Cummulative Rainfall Departure (mm)















Table D.1 Groundwater Quality Data – Alluvium

Bore ID	W/MR Goology	рН Ті	rigger		p H (Q :	L)		эН (Q2	2)	H	oH (Q3	3)		р Н (Q 4	1)	EC Trigger	EC (Q1) (µS,	′cm)	EC	(2) (μS/	cm)	EC (μS/cm)	(Q3)	EC (μS/cm) ((Q4)
Bore ID	WWF GEOLOGY	(Sui Dercentile)	(35til Dercentile)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(µS/cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CFW55R	Carrington Alluvium	7.0	8.0	7.2	7.2	7.2	-	-	7.2	7.3	7.3	7.3	7.2	7.3	7.5	6154	3380	3590	3940	-	-	4020	3460	3780	3720	3660	3720	3780
CFW57	Carrington Alluvium	7.0	8.0	7.5	7.5	7.4	-	-	7.4	7.4	7.5	7.4	7.5	7.4	7.7	6154	1467	1506	1551	-	-	1835	1945	1906	2000	2090	2050	2070
CGW52a	Carrington Alluvium	7.0	8.0	-	-	7.8	-	-	7.8	-	-	7.8	1	-	7.7	6154	-	-	1260	-	-	1381	-	-	1439	-	-	1404
CGW53a	Carrington Alluvium	7.0	8.0	-	-	7.2	-	-	7.4	-	-	7.3	1	-	7.4	6154	-	-	968	-	-	973	-	-	1054	-	-	965
CGW55a	Carrington Alluvium	7.0	8.0	-	-	7.8	-	-	8.0	-	-	7.6	-	-	8.1	6154	-	-	868	-	-	935	-	-	2760	-	-	1080
4032P	Carrington West Wing Alluvium	7.0	7.5	-	-	7.4	-	-	7.5	-	-	7.3	-	-	7.4	2775	-	-	1234	-	-	1289	-	-	1430	-	-	1413
4034P	Carrington West Wing Alluvium	7.0	7.5	-	-	nm	-	-	7.2	-	-	7.4	-	-	7.3	2775	-	-	nm	-	-	2070	-	-	1704	-	-	1632
4037P	Carrington West Wing Alluvium	7.0	7.5	-	-	7.3	-	-	7.4	-	-	7.3	-	-	7.3	2775	-	-	1204	-	-	1222	-	-	1384	-	-	1289
4040P	Carrington West Wing Alluvium	7.0	7.5	-	-	7.1	-	-	7.2	-	-	7.3	-	-	7.2	2775	-	-	1258	-	-	1319	-	-	1435	-	-	1153
CGW49	Carrington West Wing Alluvium	7.0	7.5	-	-	7.5	-	-	7.5	-	-	7.5	-	-	7.5	2775	-	-	1824	-	-	2090	-	-	2280	-	-	2150
GW-106	Carrington West Wing Alluvium	6.8	7.8	-	-	6.8	-	-	6.9	-	-	6.9	-	-	6.8	9280	-	-	8970	-	-	8680	-	-	9400	-	-	8620
CGW32	Carrington West Wing Flood Plain	6.8	7.8	-	-	7.2	-	-	7.2	-	-	7.2	-	-	7.2	9280	-	-	8910	-	-	9000	-	-	9240	-	-	8710
CGW39	Carrington West Wing Flood Plain	6.8	7.8	-	-	7.4	-	-	7.6	-	-	7.6	-	-	7.4	9280	-	-	4350	-	-	4120	-	-	4230	-	-	4100
CGW47a	Carrington West Wing Flood Plain	6.8	7.8	-	-	7.5	-	-	7.5	-	-	7.6	-	-	7.5	9280	-	-	6060	-	-	5570	-	-	4550	-	-	4120
BUNC45A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.5	-	6.6	-	-	6.7	-	-	6.7	-	4462	-	-	3070	-	2950	-	-	3180	-	-	2330	-
BZ1-1	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.5	-	7.5	-	-	7.4	-	-	7.4	-	4462	-	-	2830	-	2950	-	-	2940	-	-	2720	-
CHPZ10A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.0	-	6.8	-	-	6.9	-	-	6.9	-	4462	-	-	1463	-	1324	-	-	1394	-	-	1254	-
CHPZ12A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.8	-	6.9	-	-	6.9	-	-	7.0	-	4462	-	-	1616	-	1259	-	-	2070	-	-	1162	-
CHPZ1A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.1	-	7.2	-	-	7.1	-	-	7.1	-	4462	-	-	692	-	747	-	-	718	-	-	698	-
CHPZ2A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.1	-	7.1	-	-	7.0	-	-	7.2	-	4462	-	-	891	-	905	-	-	931	-	-	861	-
СНРΖЗА	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.9	-	6.9	-	-	6.9	-	-	6.9	-	4462	-	-	859	-	888	-	-	867	-	-	809	-
CHPZ4A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.1	-	7.0	-	-	7.1	-	-	6.9	-	4462	-	-	856	-	851	-	-	894	-	-	889	-
CHPZ8A	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.2	-	7.1	-	-	7.2	-	-	6.9	-	4462	-	-	1120	-	1260	-	-	1476	-	-	1357	-
GA3	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.8	-	6.9	-	6.7	-	-	6.6	-	-	4462	-	-	617	-	687	-	896	-	-	1063	-	-
Hobdens Well	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.2	-	7.6	-	-	7.7	-	-	7.6	-	4462	-	-	1198	-	1254	-	-	1132	-	-	1096	-
HV3(2)	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.8	-	6.9	-	6.9	-	-	6.8	-	-	4462	-	-	717	-	688	-	638	-	-	660	-	-
PZ1CH200	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	nm	-	nm	-	-	7.4	-	-	7.5	-	4462	-	-	nm	-	nm	-	-	1377	-	-	1328	-
PZ2CH400	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.0	-	nm	-	-	6.9	-	-	7.1	-	4462	-	-	1170	-	nm	-	-	1438	-	-	1361	-
PZ3CH800	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.7	-	nm	-	-	6.8	-	-	7.0	-	4462	-	-	2110	-	nm	-	-	2860	-	-	2780	-
PZ4CH1380	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	7.0	-	nm	-	-	6.9	-	-	7.1	-	4462	-	-	699	-	nm	-	-	685	-	-	668	-
PZ5CH1800	Cheshunt / North Pit Alluvium	6.6	7.5	-	-	6.9	-	nm	-	-	7.0	-	-	6.8	-	4462	-	-	141	-	nm	-	-	230	-	-	309	-
Appleyard Farm	Lemington South Alluvium	6.6	7.7	-	6.6	-	-	7.1	-	-	6.9	-	-	6.7	-	3938	-	435	-	-	584	-	-	537	-	-	385	-
C919(ALL)	Lemington South Alluvium	6.6	7.7	-	7.5	-	-	7.5	-	-	7.6	-	-	7.5	-	3938	-	704	-	-	639	-	-	681	-	-	670	-
PB01(ALL)	Lemington South Alluvium	6.6	7.7	-	6.6	-	-	6.8	-	-	6.8	-	-	7.2	-	3938	-	1140	-	-	1506	-	-	1592	-	-	7740	-
G1	West Pit Alluvium	7.1	8.6	-	7.2	7.2	-	-	7.9	-	-	7.5	-	-	7.4	10751	-	4720	4900	-	-	4500	-	-	4960	-	-	5110
G2	West Pit Alluvium	7.1	8.6	7.5	7.3	7.6	-	-	8.0	-	-	7.7	-	-	8.5	10751	5740	5520	5680	-	-	5500	-	-	5240	-	-	5280
G3	West Pit Alluvium	7.1	8.6	7.3	7.4	7.4	-	-	7.8	-	-	7.5	-	-	7.6	10751	5830	5590	5750	-	-	5600	-	-	5510	-	-	5750
GW-100	West Pit Alluvium	7.1	8.6	-	-	7.3	-	-	7.3	-	-	7.4	-	-	7.5	10751	-	-	10560	-	-	10790	-	-	10910	-	-	11060
GW-101	West Pit Alluvium	7.1	8.6	-	-	nm	-	-	nm	-	-	nm	-	-	nm	10751	-	-	nm	-	-	nm	-	-	nm	-	-	nm

Table D.2 Groundwater Quality Data – Permian Coal Measures

Bore ID		pH Trigger	pH Trigger	p	H (Q1	L)	рH	I (Q2)		pH (Q	3)		pH (Q4	4)	EC Trigger	EC (Q1) (µS,	/cm)	EC (Q2) (µS,	/cm)	EC (I	μS/cm) ((Q3)	EC (μS/cm)	(Q4)
Bore ib	WINF Geology	(Sui Dercentile)	(35til Dercentile)	Jan	Feb	Mar	Apr N	Vlay Jur	n Jul	Aug	Sep	Oct	Nov	Dec	(µS/cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CGW51a	Carrington Alluvium	6.7	7.4	-	-	7.7	-	- 7.8	- 3	-	7.5	-	-	8.3	10824	-	-	5280	•	•	4960	-	-	6040	-	-	5380
CGW52	Carrington Broonie	6.8	7.1	-	-	6.9	-	- 7.1	-	-	6.9	-	-	7.0	8628	-	-	7950	-	-	7810	-	-	7500	-	-	7630
CGW53	Carrington Broonie	6.8	7.1	-	-	6.6	-	- 6.8	3 -	-	6.7	-	-	6.8	8628	-	-	5550	1	1	6720	-	-	7200	-	-	6540
4036C	Carrington Interburden	6.7	7.4	-	-	nm	-	- nm	1 -	-	nm	-	-	6.7	10824	-	-	nm	-	-	nm	-	-	nm	-	-	3280
4051C	Carrington Interburden	6.7	7.4	-	-	6.8	-	- 6.8	- 3	-	7.1	-	-	6.8	10824	-	-	1220	-	-	1205	- 1	-	1734	-	-	1105
BZ3-1	Carrington Interburden	6.9	7.7	-	-	nm	- 1	nm -	-	6.9	-	-	6.8	-	6213	-	-	nm	-	nm	-	-	2700	-	-	2690	-
BZ8-2	Carrington Interburden	6.9	7.7	-	-	nm	- 1	nm -	-	nm	-	nm	-	-	6213	-	-	nm	-	nm	-	-	nm	-	nm	-	-
HG2	Carrington Interburden	6.9	7.7	-	-	7.5	- '	7.5 -	-	7.5	-	-	7.3	-	6213	-	-	3830	-	3730	-	-	3760	-	-	3470	-
CGW46	Carrington West Wing Bayswater	7.3	7.6	-	-	7.0	-	- 7.2	2 -	-	7.3	-	-	7.1	3531	-	-	531	-	-	564	-	-	1582	-	-	768
CGW45	Carrington West Wing LBL	6.5	7.2	-	-	nm	-	- 7.4	- 1	-	nm	-	-	nm	1894	-	-	nm	-	-	345	-	-	nm	-	-	nm
BC1a	Cheshunt Mt Arthur	6.5	7.6	-	-	6.9	- '	7.1 -	-	7.1	-	-	7.1	-	3350	-	-	995	-	1013	-	-	935	-	-	923	-
BZ1-3	Cheshunt Mt Arthur	6.5	7.6	-	-	7.4	- '	7.4 -	-	7.4	-	-	7.3	-	3350	-	-	1110	-	1165	-	-	1213	-	-	1179	-
BZ2A(1)	Cheshunt Mt Arthur	6.5	7.6	-	-	6.4	-	6.5 -	-	6.5	-	-	6.6	-	3350	-	-	1386	-	1338	-	-	1337	-	-	1366	-
BZ3-3	Cheshunt Mt Arthur	6.5	7.6	-	-	6.2	- 1	6.4 -	-	6.3	-	-	6.3	-	3350	-	-	1297	-	1521	-	-	1322	-	-	1324	-
BZ4A(2)	Cheshunt Mt Arthur	6.5	7.6	-	-	6.4	- 1	nm -	-	nm	-	nm	-	-	3350	-	-	1726	-	nm	-	-	nm	-	nm	-	-
CHPZ12D	Cheshunt Mt Arthur	6.5	7.6	-	-	6.9	- '	7.0 -	-	6.9	-	-	7.3	-	3350	-	-	1304	-	1385	-	-	1332	-	-	1343	-
CHPZ3D	Cheshunt Mt Arthur	6.5	7.6	-	-	6.4	-	6.4 -	-	6.6	-	-	6.6	-	3350	-	-	990	-	1020	-	-	977	-	<u> </u>	984	-
CHPZ8D	Cheshunt Mt Arthur	6.5	7.6	-	-	7.1	- '	7.2 -	-	7.3	-	-	7.1	-	3350	-	-	1121	-	1133	-	-	1151	-	-	1168	-
HG2a	Cheshunt Mt Arthur	6.5	7.6	-	-	7.1	- '	7.3 -	-	7.3	-	-	7.2	-	3350	-	-	2510	-	2620	-	-	2650	-	-	2550	-
BUNC45D	Cheshunt Piercefield	6.4	6.8	-	-	6.7	-	6.7 -	-	6.7	-	-	6.8	-	2596	-	-	2200	-	2220	-	<u> </u>	2290	-	-	2280	-
C130(AFS1)	Lemington South Arrowfield	6.8	7.5	N	R (6N	1)	- '	7.4 -		NR (6N	Л)	-	7.3	-	15324		NR (6M)	-	12520	-	1	NR (6M)	1	-	13000	-
D406(AFS)	Lemington South Arrowfield	6.8	7.5	N	R (6N	1)	-	6.9 -		NR (6N	Л)	-	7.0	-	15324		NR (6M)	-	11040	-	n	NR (6M)	,	-	11400	-
D510(AFS)	Lemington South Arrowfield	6.8	7.5	N	R (6N	1)	- 1	nm -		NR (6N	Л)	-	nm	-	15324		NR (6M)	-	nm	-	1	NR (6M)	1	-	nm	-
D612(AFS)	Lemington South Arrowfield	6.8	7.5	N	R (6N	1)	- 1	nm -		NR (6N	Л)	-	nm	-	15324		NR (6M)	-	nm	-	r I	NR (6M)	,	<u> </u>	nm	-
B334(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.2 -		NR (6N	Л)	-	7.0	-	12440		NR (6M)	-	7080	-		NR (6M)	,	<u> </u>	7760	-
B631(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- 1	6.8 -		NR (6N	Л)	-	6.7	-	12440		NR (6M)	-	12030	-	1	NR (6M)	,	<u> </u>	12860	-
B925(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.3 -		NR (6N	Л)	-	7.0	-	12440		NR (6M)	-	4510	-	۲ ۱	NR (6M)		<u> </u>	5050	-
C122(BFS)	Lemington South Bowfield	6.7	7.9	-	nm	-	- 1	nm -	-	nm	-	-	nm	-	12440		nm		-	nm	-	<u> </u>	nm	<u> </u>	<u> </u>	nm	-
C130(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.4 -		NR (6N	Л)	-	7.5	-	12440		NR (6M)	-	5050	-		NR (6M)		<u> </u>	4900	-
C317(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.2 -		NR (6N	Л)	-	7.2	-	12440		NR (6M)	-	9640	-		NR (6M)		<u> </u>	10220	-
C613(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.0 -		NR (6N	Л)	-	7.2	-	12440		NR (6M)	-	8610	-		NR (6M)		<u> </u>	8940	-
C621(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	- '	7.2 -		NR (6N	<u>л)</u>	-	7.1	-	12440		NR (6M)	-	7430	-	۲ 	NR (6M)		- <u> </u>	7560	-
C630(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	-	7.9 -		NR (6N	<i>и</i>)	-	7.8	-	12440		NR (6M)	-	4680	-		NR (6M)		- <u> </u>	4720	-
D010(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	-	7.3 -		NR (6N	A)	-	7.1	-	11408		NR (6M)	-	7570	-		NR (6M)		-	9800	-
D214(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	-	6.2 -		NR (6N	<i>и</i>)	-	7.7	-	12440		NR (6M)	-	113	-		NR (6M)		- <u> </u>	7580	-
D317(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	-	6.8 -		NR (6N	<u>л)</u>	-	6.8	-	12440		NR (6M)	-	3000	-		NR (6M)		-	3000	-
D406(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6IV	1)	-	7.5 -		NR (6N	<i>v</i> 1)	-	7.6	-	12440		NR (6M)	-	7200	-		NR (6M)		-	7270	-
D510(BFS)	Lemington South Bowfield	6.7	7.9	N	NR (6M)		- 1	6.9 -		NR (6N	<i>v</i> 1)	-	7.3	-	12440		NR (6M)	-	3920	-		NR (6M)		-	8310	-
D612(BFS)	Lemington South Bowfield	6.7	7.9	N	R (6N	1)	-	6.9 -		NR (6N	<u>л)</u>	-	7.8	-	12440		NR (6M)	-	11180	-		NR (6M)		-	11550	-
D807(BFS)	Lemington South Bowfield	6.7	7.9	N	K (6IV	1)	-	/.0 -	_	NK (6N	vi)	-	6.9	-	12440		NR (6M)	-	9280	-		NR (6M)		-	6660	-
D010(GM)	Lemington South Glen Munro	6.7	7.1	N	R (6IV	1)	-	6.9 -		NR (6N	/1)	-	6.9	-	11408		NR (6M)	-	9290	-	r 	NR (6M)		-	11470	-
C130(ALL)	Lemington South Interburden	6.8	7.0	┠─┤	7.0		-	/.0 -		6.9	-	-	6.9	-	22700		19590		-	19810	-	-	21100	<u> </u>	-	21900	-
LUG Bore	Lemington South Mt Arthur	No T	rigger		7.2			7.2 -	-	7.3	-	-	7.1	-	No Trigger		8340		-	8400	-	-	8500	<u> </u>	-	8560	-
B425(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	K (6IV	1)	-	/.0 -	_	NK (6N	vi)	-	7.3	-	20240		NR (6M)	-	13460	-		NR (6M)		-	13290	-
B631(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	K (6IV	1)	-	6.9 -		NK (6N	vi)	-	6.5	-	20240		NR (6M)	-	12150	-		NR (6M)		-	12690	-
C122(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	к (6N	1)	-	7.8 -		NR (6N	/1)	-	6.9	-	20240		NR (6M)	-	13630	-	1	NR (6M)		<u> </u>	14360	<u> -</u>

Table D.2 Groundwater Quality Data – Permian Coal Measures

Poro ID	W/MD Coology	pH Trigger	pH Trigger	р	H (Q1)		рН (Q2	2)	р	H (Q3)		p	H (Q4)	EC Trigger	EC ((Q1) (µS	/cm)	EC (Q2) (µS	j/cm)	EC (μS/cm)	(Q3)	EC (μS/cm) (Q4)
Bore ID	wivir deology	(Sui Dorcontilo)	(35ui Dorcontilo)	Jan	Feb Ma	Apr	May	Jun	Jul	Aug S	iep	Oct	Nov	Dec	(µS/cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C130(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	R (6M)	-	6.6	-	N	R (6M)		-	6.5	-	20240	_	NR (6M)	-	19320	-		NR (6M)	-	20800	-
C317(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	R (6M)	-	7.6	-	N	R (6M)		-	7.6	-	20240	-	NR (6M)	1	5130	-		NR (6M)	-	5290	-
C809(GM/WDH)	Lemington South Woodlands Hill	6.6	7.6	N	R (6M)	-	7.1	-	N	R (6M)		-	7.3	-	20240	-	NR (6M)	1	9650	-		NR (6M)	-	9990	-
D010(WDH)	Lemington South Woodlands Hill	6.6	7.6	N	R (6M)	-	7.1	-	N	R (6M)		-	7.0	-	20240	-	NR (6M)	-	7130	-		NR (6M)	-	9120	-
SR002	Southern Bayswater Seam	No Ti	rigger	N	R (6M)	-	-	6.9	N	R (6M)		-	-	6.9	No Trigger		NR (6M)	-	-	13350		NR (6M)	-	-	12740
SR003	Southern Bayswater Seam	No Ti	rigger	N	R (6M)	-	-	7.0	N	R (6M)		-	-	7.2	No Trigger	-	NR (6M)	-	-	9590		NR (6M)	-	-	8470
SR004	Southern Bayswater Seam	No Ti	rigger	N	R (6M)	-	-	6.8	N	R (6M)		-	-	6.7	No Trigger	_	NR (6M)	-	-	12010		NR (6M)	-	-	11400
SR005	Southern Bayswater Seam	No Ti	rigger	N	R (6M)	-	-	6.4	N	R (6M)		-	-	6.4	No Trigger		NR (6M)	-	-	3480		NR (6M)	-	-	2910
SR006	Southern Bayswater Seam	No Ti	rigger	N	R (6M)	-	-	6.9	N	R (6M)		-	-	6.9	No Trigger		NR (6M)	-	-	11270		NR (6M)	-	-	10820
SR001	Southern Coal	No Ti	rigger	N	R (6M)	-	-	6.7	N	R (6M)		-	-	6.7	No Trigger	-	NR (6M)	-	-	14840		NR (6M)	-	-	13440
SR010	Southern Conglomerate and Warkworth Seam	No Ti	rigger	N	R (6M)	-	-	7.7	N	R (6M)		-	-	7.2	No Trigger	I	NR (6M)	-	-	1024		NR (6M)	-	-	6190
SR009	Southern Lemington Seam	No Ti	rigger	N	R (6M)	-	-	7.3	N	R (6M)		-	-	7.4	No Trigger	-	NR (6M)	1	-	6020		NR (6M)	-	-	6300
SR011	Southern Mt Arthur Seam and underburden	No Ti	rigger	N	R (6M)	-	-	6.6	N	R (6M)		-	-	6.6	No Trigger	-	NR (6M)	1	-	15740		NR (6M)	-	-	16620
SR012	Southern Overburden - conglomerate and sandstone	No Ti	rigger	N	R (6M)	-	-	6.7	N	R (6M)		-	-	6.8	No Trigger	-	NR (6M)	-	-	15650		NR (6M)	-	-	13140
SR007	Southern Overburden and Vaux Seam	No Ti	rigger	N	R (6M)	-	-	6.5	N	R (6M)		-	-	6.7	No Trigger	I	NR (6M)	-	-	5830		NR (6M)	-	-	7150
SR008	Southern Siltstone/sandstone below Lemington Seam	No Ti	lo Trigger		R (6M)	-	-	7.0	N	R (6M)		-	-	6.9	No Trigger	-	NR (6M)	-	-	12300		NR (6M)	-	-	14550
NPz2	West Pit Sandstone/Siltstone	6.9	8	-	- 7.0	-	-	7.0	-	- 7	7.0	-	-	7.0	13428			13980	-	-	13620	-	-	13980	-	-	14410
NPz3	West Pit Sandstone/Siltstone	6.9	8	-	- nm	-	-	nm	-	- r	nm	-	-	nm	13428			nm	-	-	nm	-	-	nm	-	-	nm
NPz5	West Pit Sandstone/Siltstone	6.9	8	-	- nm	-	-	nm	-	- r	nm	-	-	nm	13428			nm	-	-	nm	-	-	nm	-	-	nm

Note: NR (6m) = not required (6 monthly monitoring only)

Table D.3 Groundwater Quality Data – Spoil

Poro ID	W/MD Coology	pH Trigger	pH Trigger		pH (Q	1)		pH (Q2	2)	F	oH (Q3	3)		pH (Q4	I)	EC Trigger	EC (Q1) (µS	/cm)	EC (Q2) (µS/	/cm)	EC (μS/cm)	(Q3)	EC (μS/cm)	(Q4)
BOIEID	WINF Geology	(Sui Dercentile)	(95til	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(µS/cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GW-107	Carrington Spoil	No T	rigger	-	-	nm	-	nm	-	nm	-	-	-	-	nm	No Trigger	-	-	nm	-	nm	-	nm	-	-	-	-	nm
GW-108	Carrington Spoil	No T	rigger	-	-	nm	-	nm	-	nm	-	-	-	-	nm	No Trigger	•	-	nm	-	nm	•	nm	-	•	-	-	nm
4116P	North Pit Spoil	6.5	7.8	-	-	7.0	-	6.9	-	7.1	-	-	7.1	-	-	12460	1	-	11380	-	11590	1	11390	-	•	11620	-	-
4119P	North Pit Spoil	6.5	7.8	-	-	6.8	-	6.7	-	7.1	-	-	6.8	-	-	12460	1	-	5490	-	5780	1	3530	-	•	5460	-	-
DM1	North Pit Spoil	6.5	7.8	-	-	6.4	-	6.5	-	6.5	-	-	6.6	-	-	12460	-	-	9790	-	10270	-	9580	-	-	9820	-	-
DM3	North Pit Spoil	6.5	7.8	-	-	nm	-	nm	-	nm	-	-	6.5	-	-	12460	1	-	nm	-	nm	1	nm	1	1	9730	-	-
DM4	North Pit Spoil	6.5	7.8	-	-	6.9	-	6.9	-	6.9	-	-	6.9	-	-	12460	1	-	6000	-	5940	1	5750	-	•	5800	-	-
DM7	North Pit Spoil	6.5	7.8	-	-	8.3	-	7.3	-	7.3	-	-	7.5	-	-	12460	1	-	7070	-	7050	1	6520	1	•	7030	-	-
GW-114	North Pit Spoil	6.5	7.8	-	-	6.5	-	6.6	-	6.8	-	-	6.8	-	-	12460	-	-	8880	-	8560	-	7350	-	-	8550	-	-
GW-115	North Pit Spoil	6.5	7.8	-	-	6.9	-	6.8	-	7.0	-	-	6.8	-	-	12460	•	-	4900	-	7350	•	5600	-	•	7050	-	-
MB14HVO01	North Pit Spoil	6.5	7.8	-	-	6.7	-	6.7	-	7.0	-	-	6.8	-	-	12460	1	-	7420	-	7400	1	5950	1	•	7310	-	-
MB14HVO02	North Pit Spoil	6.5	7.8	-	-	6.8	-	6.7	-	6.9	-	-	6.9	-	-	12460	1	-	7220	-	7140	1	6560	1	•	7100	-	-
MB14HVO03	North Pit Spoil	6.5	7.8	-	-	6.8	-	6.9	-	7.0	-	-	7.0	-	-	12460	-	-	5550	-	5160	-	3910	-	-	5450	-	-
MB14HVO04	North Pit Spoil	6.5	7.8	-	-	6.8	-	6.9	-	6.9	-	-	7.0	-	-	12460	-	-	5920	-	5790	-	5670	-	-	5760	-	-
MB14HVO05	North Pit Spoil	6.5	7.8	-	-	6.9	-	6.8	-	6.9	-	-	6.9	-	-	12460	-	-	7190	-	7240	-	7050	-	-	7070	-	-










































500

0

-500

-1000

-1500

-2000

-2500

-3000

500

0

DM3

GW-115

MB14HVO04

CRD (SILO)

0 0 -500 -500 -1000 -1500 -2500 -2500 -2500 -2500 -3000 -2500 -3000 -2500

Cumulative Rainfall Departure (mm)



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500

0

-500

-1000

-1500

-2000

-2500

-3000

121.24

D510(AFS)

CRD (SILO)

30.22 130.23

Departure (mm)

Cumulative Rainfall











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500

0

-500

-1000

-1500

-2000

-2500

-3000

500

0

-500

-1000

-1500

-2000

-2500

-3000

Jan 24

Cumulative Rainfall Departure (mm)

120.24

Cumulative Rainfall Departure (mm)









2023 Q1 Comprehensive Water Quality Analysis:

			Depth to		Field	Total	Carbonate	Hydroxido	Ricarbonato	Total	Sulfate as	Discoluted	Discoluted	Discoluted	Dissolved	Discolved	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	
Roro ID	Data	Geology	Water from	Field pH (pH	Electrical	Dissolved	Alkalinity	Alkalinity as	Alkalinity as	Alkalinity as	Sunace as	Calcium	Chlorido	Magnosium	Potassium	Sodium	Aluminium	Arconic	Boron	Cadmiu	Cohalt	Coppe	Load	Morcupi	Nickol	Salanium	Total Zinc
Dore ib	Date	Geology	Stand Pipe	unit)	Conductivity	Solids	as CaCO3	CaCO2 (mg/L)	CaCO2 (mg/L)	CaCO3	(mg/1)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ma/l)	(ma/t)	(mg/l)	(ma/1)	m (mg/l)	(mg/I)	r i	(mg/I)	(mg/l)	(mg/L)	(mg/L)	(mg/L)
			(mbToC)		(µS/cm)	(mg/L)	(mg/L)	CacO3 (IIIg/L)	cacos (mg/t)	(mg/L)	(116/4)	(116/1)	(116/1)	(116/1)	(116/1)	(1116/ 5/	(1116/14)	(116/1)	(116/1)	···· (···6/ 5)	(116/1)	(mg/L)	(116/5)	(116/1)	(116/1)	(116/1)	
4032P	6/03/2023	Carrington West Wing_Alluvium	8.76	7.4	1234	745	<1	<1	412.00	412.00	32.00	47.00	153	47.00	2.00	142.00	9.75	0.002	0.06	< 0.0001	0.014	0.021	0.003	< 0.0001	0.017	<0.01	0.071
4037P	6/03/2023	Carrington West Wing_Alluvium	10.12	7.3	1204	703	<1	<1	302.00	302.00	40.00	64.00	193	54.00	1.00	95.00	1.21	0.001	<0.05	< 0.0001	0.004	0.015	0.001	< 0.0001	0.004	<0.01	0.021
4116P	7/03/2023	North Pit_Spoil	22.07	7.0	11380	7690	<1	<1	884.00	884.00	629.00	174.00	3250	390.00	20.00	1890.00	9.40	0.003	0.20	0.0001	0.013	0.015	0.017	< 0.0001	0.025	0.020	0.232
BUNC45A	3/03/2023	Cheshunt / North Pit_Alluvium	19.68	6.5	3070	1740	<1	<1	470.00	470.00	67.00	98.00	762	68.00	8.00	470.00	0.16	< 0.001	0.09	< 0.0001	0.001	0.001	< 0.001	< 0.0001	0.015	<0.01	0.016
BUNC45D	3/03/2023	Cheshunt_Piercefield	24.83	6.7	2200	1310	<1	<1	734.00	734.00	1.00	77.00	391	58.00	10.00	366.00	0.40	0.001	0.13	< 0.0001	< 0.001	0.001	0.002	< 0.0001	0.007	<0.01	0.026
BZ1-1	1/03/2023	Cheshunt / North Pit_Alluvium	17.66	7.5	2830	1580	<1	<1	570.00	570.00	89.00	18.00	492	41.00	9.00	541.00	0.25	< 0.001	0.06	< 0.0001	< 0.001	0.005	< 0.001	< 0.0001	0.002	<0.01	0.010
BZ1-3	1/03/2023	Cheshunt_Mt Arthur	46.50	7.4	1110	589	<1	<1	366.00	366.00	29.00	14.00	128	25.00	9.00	202.00	0.29	< 0.001	0.08	< 0.0001	< 0.001	0.006	< 0.001	< 0.0001	0.020	<0.01	0.025
CFW57	20/01/2023	Carrington_Alluvium	10.48	7.5	1467	880	<1	<1	436.00	436.00	50.00	18.00	202	24.00	2.00	292.00	0.32	< 0.001	<0.05	< 0.0001	0.000	< 0.001	< 0.001	< 0.0001	0.007	<0.01	< 0.005
CGW39	6/03/2023	Carrington West Wing_Flood Plain	10.15	7.4	4350	2540	<1	<1	785.00	785.00	159.00	71.00	865	110.00	5.00	658.00	0.14	< 0.001	0.07	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.0001	0.015	0.020	< 0.005
CGW46	6/03/2023	Carrington West Wing_Bayswater	11.32	7.0	531	368	<1	<1	186.00	186.00	<1	25.00	40	14.00	50.00	25.00	1.16	0.002	0.05	< 0.0001	0.002	0.007	0.002	< 0.0001	0.010	<0.01	0.050
CGW47a	7/03/2023	Carrington West Wing_Flood Plain	9.35	7.5	6060	3890	<1	<1	689.00	689.00	157.00	143.00	1460	243.00	7.00	850.00	0.04	< 0.001	0.09	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.0001	0.002	0.010	0.013
CHPZ10A	2/03/2023	Cheshunt / North Pit_Alluvium	7.86	7.0	1463	960	<1	<1	435.00	435.00	133.00	143.00	167	91.00	2.00	64.00	1.39	< 0.001	<0.05	< 0.0001	0.003	0.001	< 0.001	< 0.0001	0.009	0.010	< 0.005
CHPZ12A	3/03/2023	Cheshunt / North Pit_Alluvium	7.70	6.8	1616	1150	<1	<1	353.00	353.00	129.00	153.00	246	94.00	1.00	67.00	0.02	< 0.001	0.05	< 0.0001	< 0.001	< 0.001	<0.001	< 0.0001	0.003	0.020	< 0.005
CHPZ12D	3/03/2023	Cheshunt_Mt Arthur	7.90	6.9	1304	882	<1	<1	552.00	552.00	<1	16.00	127	12.00	8.00	276.00	0.07	< 0.001	0.10	< 0.0001	< 0.001	< 0.001	<0.001	< 0.0001	0.001	<0.01	0.011
CHPZ1A	2/03/2023	Cheshunt / North Pit_Alluvium	10.07	7.1	692	406	<1	<1	279.00	279.00	28.00	49.00	56	33.00	2.00	59.00	0.03	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	<0.001	< 0.0001	0.001	<0.01	< 0.005
CHPZ2A	2/03/2023	Cheshunt / North Pit_Alluvium	9.93	7.1	891	474	<1	<1	249.00	249.00	52.00	51.00	119	43.00	<1	85.00	<0.01	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	<0.001	< 0.0001	0.009	<0.01	< 0.005
CHPZ3A	3/03/2023	Cheshunt / North Pit_Alluvium	8.03	6.9	859	524	<1	<1	221.00	221.00	78.00	58.00	128	43.00	1.00	59.00	0.47	< 0.001	<0.05	< 0.0001	< 0.001	0.003	< 0.001	< 0.0001	0.006	< 0.01	< 0.005
CHPZ3D	3/03/2023	Cheshunt_Mt Arthur	8.96	6.4	990	492	<1	<1	402.00	402.00	<1	11.00	88	11.00	6.00	207.00	4.55	< 0.001	0.12	< 0.0001	0.002	0.006	<0.001	< 0.0001	0.017	<0.01	0.012
CHPZ4A	2/03/2023	Cheshunt / North Pit_Alluvium	10.50	7.1	856	494	<1	<1	285.00	285.00	42.00	64.00	85	40.00	2.00	68.00	0.16	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	<0.001	< 0.0001	0.005	<0.01	< 0.005
CHPZ8A	3/03/2023	Cheshunt / North Pit_Alluvium	5.12	7.2	1120	734	<1	<1	452.00	452.00	76.00	130.00	97	66.00	<1	41.00	0.17	< 0.001	0.05	< 0.0001	< 0.001	0.001	< 0.001	< 0.0001	0.002	< 0.01	< 0.005
CHPZ8D	3/03/2023	Cheshunt_Mt Arthur	5.31	7.1	1121	592	<1	<1	370.00	370.00	70.00	110.00	149	59.00	2.00	42.00	0.70	0.001	<0.05	< 0.0001	< 0.001	0.004	0.002	< 0.0001	0.004	<0.01	0.044
G1	16/01/2023	West Pit_Alluvium	1.74	7.2	4900	3050	<1	<1	550.00	550.00	706.00	83.00	961	98.00	3.00	737.00	0.03	< 0.001	0.13	< 0.0001	0.000	< 0.001	<0.001	< 0.0001	0.039	<0.01	0.024
G2	16/01/2023	West Pit_Alluvium	1.35	7.5	5740	3800	<1	<1	666.00	666.00	964.00	51.00	1050	164.00	7.00	1120.00	0.11	< 0.001	0.21	< 0.0001	0.000	< 0.001	0.001	< 0.0001	0.005	< 0.01	< 0.005
G3	16/01/2023	West Pit_Alluvium	1.86	7.3	5830	3640	<1	<1	700.00	700.00	787.00	52.00	1180	116.00	4.00	1180.00	0.02	< 0.001	0.18	< 0.0001	0.000	< 0.001	< 0.001	< 0.0001	0.002	<0.01	< 0.005
MB14HVO01	23/03/2023	North Pit_Spoil	30.83	6.7	7420	5220	<1	<1	754.00	754.00	1430.00	206.00	1460	231.00	24.00	1100.00	< 0.01	0.064	0.11	< 0.0001	0.054	< 0.001	< 0.001	< 0.0001	0.062	< 0.01	0.007
MB14HVO02	23/03/2023	North Pit_Spoil	30.47	6.8	7220	5150	<1	<1	754.00	754.00	1280.00	189.00	1470	232.00	25.00	1070.00	< 0.01	0.182	0.09	< 0.0001	0.040	< 0.001	< 0.001	< 0.0001	0.061	<0.01	0.013
MB14HVO03	23/03/2023	North Pit_Spoil	30.45	6.8	5550	3800	<1	<1	794.00	794.00	876.00	160.00	1060	160.00	23.00	853.00	< 0.01	0.163	0.10	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.0001	0.004	<0.01	< 0.005
MB14HVO04	29/03/2023	North Pit_Spoil	25.34	6.8	5920	4530	<1	<1	728.00	728.00	1170.00	310.00	1090	248.00	22.00	823.00	1.06	0.104	<0.05	< 0.0001	0.028	0.003	< 0.001	< 0.0001	0.086	< 0.01	0.095
MB14HVO05	23/03/2023	North Pit_Spoil	31.07	6.9	7190	5240	<1	<1	777.00	777.00	1650.00	154.00	1350	284.00	32.00	1070.00	0.18	0.006	0.08	< 0.0001	0.033	< 0.001	< 0.001	< 0.0001	0.036	< 0.01	0.122
PZ2CH400	3/03/2023	Cheshunt / North Pit_Alluvium	8.28	7.0	1170	746	<1	<1	284.00	284.00	121.00	69.00	151	47.00	7.00	92.00	0.63	< 0.001	< 0.05	< 0.0001	0.003	0.003	< 0.001	< 0.0001	0.004	< 0.01	0.032
PZ3CH800	2/03/2023	Cheshunt / North Pit_Alluvium	8.91	6.7	2110	1370	<1	<1	485.00	485.00	253.00	170.00	338	96.00	4.00	176.00	0.68	< 0.001	<0.05	< 0.0001	0.003	0.005	0.005	< 0.0001	0.010	< 0.01	0.072

Additionl analsyses for PZ series of bores:

Bore ID	Date	Geology	Total Antimony (mg/L)	Total Beryllium (mg/L)	Total Cobalt (mg/L)	Total Flouride (mg/L)	Total Iron (mg/L)	Total Manganese (mg/L)	Total Phosphorus as P (mg/L)	Total Rubidium (mg/L)	Total Silicon (mg/L)	Total Strontium (mg/L)	Ammonia as N (mg/L)	Nitrite + Nitrate as N (mg/L)
PZ2CH400	3/03/2023	Cheshunt / North Pit_Alluvium	<0.001	< 0.001	0.003	<0.1	1.64	0.33	0.52	0.002	0.000	0.57	0.00	0.06
PZ3CH800	2/03/2023	Cheshunt / North Pit_Alluvium	<0.001	< 0.001	0.003	0.10	< 0.05	0.05	0.31	0.002	0.000	1.39	0.00	0.63

2023 Q2 Comprehensive Water Quality Analysis:

Bore ID	Date	Geology	Depth to Water from Stand Pipe (mbToC)	Field pH (pH unit)	Field Electrical Conductivity (µS/cm)	Total Dissolved Solids (mg/L)	Carbonat e Alkalinity as CaCO3 (mg/L)	Hydroxide Alkalinity as CaCO3 (mg/L)	Bicarbonat e Alkalinity as CaCO3 (mg/L)	Total Alkalinity as CaCO3 (mg/L)	Sulfate as SO4 (mg/L)	Dissolved Calcium (mg/L)	Dissolved Chloride (mg/L)	Dissolved Magnesium (mg/L)	Dissolved Potassium (mg/L)	Dissolved Sodium (mg/L)	Total Aluminium (mg/L)	Total Arsenic (mg/L)	Total Boron (mg/L)	Total Cadmium (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Mercury (mg/L)	Total Nickel (mg/L)	Total Selenium (mg/L)	Total Zinc (mg/L)
4116P	3/05/2023	North Pit_Spoil	22.07	6.9	11590	7050	<1	<1	1010	1010	864	168	3170	453	28	1880	6.97	0.002	0.11	0.0002	0.018	0.01	< 0.0001	0.02	< 0.01	0.06
4119P	3/05/2023	North Pit_Spoil	7.65	6.7	5780	3910	<1	<1	843	843	1190	219	877	231	23	888	0.20	0.12	0.10	< 0.0001	0.003	< 0.001	< 0.0001	0.12	< 0.01	0.05
CFW55R	9/06/2023	Carrington_Alluvium	10.74	7.2	4020	2290	<1	<1	650	650	389	21	726	52	13	808	1.57	< 0.001	0.09	< 0.0001	0.002	< 0.001	< 0.0001	0.01	< 0.01	0.01
CFW57	8/06/2023	Carrington_Alluvium	11.03	7.4	1835	1060	<1	<1	512	512	83	22	266	36	2	348	0.12	< 0.001	< 0.05	< 0.0001	0.002	< 0.001	< 0.0001	0.03	< 0.01	< 0.005

2023 Q3 Comprehensive Water Quality Analysis:

			Depth to		Field Electrical	Total	Carbonate	Hydroxide	Bicarbonate	Total		Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Total	Total	Total	Total	Total	Total	Total	Total	Total	
Bore ID	Date	Geology	Water from	Field pH (pH	Conductivity	Dissolved	Alkalinity	Alkalinity as	Alkalinity as	Alkalinity as	Sulfate as	Calcium	Chloride	Magnesium	Potassium	Sodium	Aluminium	Arsenic	Boron	Cadmium	Coppe	Lead	Mercury	Nickel	Selenium	Total Zinc
			Stand Pipe	unit)	(µS/cm)	Solids	as CaCO3	CaCO3 (mg/L)	CaCO3 (mg/L)	CaCO3	SO4 (mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	r	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
40220	25 (00 (2022		(mbToC)	7.0	4.420	(mg/L)	(mg/L)	. 20	500	(mg/L)	45	62	470	60		400	22.0	0.000	0.07	0.0000	(mg/L)	0.014	0.000	0.050	0.000	0.220
4032P	25/09/2023	Carrington West Wing_Alluvium	9.55	7.3	1430	850	< 20	< 20	500	500	45	63	1/0	68	4.4	180	22.0	0.006	0.07	0.0002	0.100	0.011	0.000	0.058	0.009	0.230
4034P	25/09/2023	Carrington West Wing_Alluvium	11.30	7.4	1704	990	< 20	< 20	500	500	//	63	260	81	4.1	200	12.0	0.010	0.07	< 0.0002	0.110	0.010	0.000	0.058	0.011	0.200
4037P	25/09/2023	Carrington West Wing_Alluvium	10.89	7.3	1384	800	< 20	< 20	370	370	45	70	240	66	2.0	120	2.9	0.003	< 0.05	< 0.0002	0.046	0.010	0.000	0.014	0.006	0.053
BUINC45A	1/08/2023	Cheshunt / North Pit_Alluvium	20.12	6.7	3180	1200	<1	<1	489	489	00	64	172	64 E4	0.0	454	0.2	0.001	0.09	<0.0001	0.002	<0.001	<0.0001	0.002	<0.01	0.019
B0INC43D	2/08/2023	Cheshunt / North Bit Allunium	19.09	7.4	2230	1500	<1	<1	601	601	08	17	408		3.0	500	0.5	0.001	0.14	0.0001	0.002	0.001	<0.0001	0.009	<0.01	0.013
B71-3	2/08/2023	Cheshunt Mt Arthur	46.54	7.4	1213	646	<1	<1	303	303	31	1/	156	45	10.0	232	4.5	<0.003	0.00	<0.0002	0.135	<0.014	<0.0001	0.021	<0.01	0.031
CEW57	19/07/2023	Carrington Alluvium	11.16	7.4	1945	1090	<1	<1	532	532	70	28	250	45	2.0	348	0.5	<0.001	0.07	<0.0001	0.001	<0.001	<0.0001	0.017	<0.01	<0.005
CGW39	25/09/2023	Carrington West Wing Flood Plain	10.67	7.6	4230	2200	< 20	< 20	790	790	150	62	960	110	5.9	690	< 0.05	0.001	0.07	< 0.0002	0.001	< 0.001	< 0.0001	0.012	0.017	< 0.005
CGW46	25/09/2023	Carrington West Wing Bayswater	12.04	7.3	1582	910	< 20	< 20	420	420	45	43	210	41	54.0	140	2.4	0.004	0.06	< 0.0002	0.015	0.002	0.000	0.013	0.005	0.047
CGW47a	25/09/2023	Carrington West Wing Flood Plain	10.03	7.6	4550	2400	< 20	< 20	800	800	140	82	1000	150	6.5	670	0.3	0.001	0.07	< 0.0002	0.001	< 0.001	< 0.0001	0.008	0.014	0.010
CHPZ10A	1/08/2023	Cheshunt / North Pit Alluvium	8.70	6.9	1394	911	<1	<1	432	432	124	118	184	82	2.0	59	0.4	< 0.001	< 0.05	< 0.0001	0.001	< 0.001	< 0.0001	0.008	< 0.01	< 0.005
CHPZ12A	1/08/2023	Cheshunt / North Pit_Alluvium	8.58	6.9	2070	1410	<1	<1	330	330	159	176	315	123	1.0	73	0.0	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.01	< 0.005
CHPZ12D	1/08/2023	Cheshunt_Mt Arthur	8.79	6.9	1332	774	<1	<1	574	574	1	23	134	14	9.0	271	0.0	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.01	< 0.005
CHPZ1A	2/08/2023	Cheshunt / North Pit_Alluvium	10.93	7.1	718	382	<1	<1	272	272	28	55	65	35	2.0	60	0.1	< 0.001	0.19	< 0.0001	0.001	< 0.001	< 0.0001	0.002	< 0.01	< 0.005
CHPZ2A	2/08/2023	Cheshunt / North Pit_Alluvium	10.74	7.0	931	502	<1	<1	269	269	58	53	131	46	<1	84	0.0	< 0.001	<0.05	<0.0001	< 0.001	< 0.001	< 0.0001	< 0.001	<0.01	< 0.005
CHPZ3A	1/08/2023	Cheshunt / North Pit_Alluvium	8.91	6.9	867	572	<1	<1	224	224	77	52	123	44	3.0	62	1.7	< 0.001	<0.05	<0.0001	0.010	< 0.001	< 0.0001	0.005	<0.01	0.008
CHPZ3D	1/08/2023	Cheshunt_Mt Arthur	9.14	6.6	977	568	<1	<1	419	419	<1	6	91	8	5.0	204	0.1	< 0.001	0.11	< 0.0001	< 0.001	< 0.001	< 0.0001	0.002	< 0.01	< 0.005
CHPZ4A	1/08/2023	Cheshunt / North Pit_Alluvium	11.31	7.1	894	504	<1	<1	284	284	44	61	105	41	2.0	66	0.1	< 0.001	<0.05	<0.0001	< 0.001	<0.001	< 0.0001	< 0.001	<0.01	<0.005
CHPZ8A	1/08/2023	Cheshunt / North Pit_Alluvium	6.08	7.2	1476	942	<1	<1	559	559	132	154	172	93	<1	43	1.0	< 0.001	0.05	< 0.0001	0.003	< 0.001	< 0.0001	0.006	<0.01	0.007
CHPZ8D	1/08/2023	Cheshunt_Mt Arthur	6.25	7.3	1151	748	<1	<1	397	397	66	109	160	66	2.0	45	1.6	0.003	<0.05	<0.0001	0.011	< 0.001	< 0.0001	0.006	<0.01	0.026
G1	26/09/2023	West Pit_Alluvium	1.36	7.5	4960	3000	< 20	< 20	730	730	1000	110	900	110	4.6	1100	0.3	< 0.001	0.09	< 0.0002	0.004	0.004	< 0.0001	0.006	< 0.001	0.032
G2	26/09/2023	West Pit_Alluvium	0.95	7.7	5240	3400	< 20	< 20	740	740	1100	39	980	160	8.8	1200	0.1	< 0.001	0.27	< 0.0002	< 0.001	< 0.001	< 0.0001	0.002	< 0.001	< 0.005
G3	26/09/2023	West Pit_Alluvium	1.31	7.5	5510	2900	< 20	< 20	820	820	990	66	1100	140	5.6	1300	0.7	< 0.001	0.22	< 0.0002	0.018	0.004	< 0.0001	0.007	< 0.001	0.093
GW-100	26/09/2023	West Pit_Alluvium	4.10	7.4	10910	6900	< 20	< 20	3000	3000	300	10	2300	110	52.0	2900	0.9	0.001	0.37	< 0.0002	0.005	0.001	< 0.0001	0.010	0.002	0.009
GW-106	25/09/2023	Carrington West Wing_Flood Plain	23.42	6.9	9400	5500	< 20	< 20	1100	1100	130	140	2500	240	28.0	1400	< 0.05	< 0.001	0.13	< 0.0002	0.002	< 0.001	< 0.0001	0.016	0.006	0.011
Hobdens Well	1/08/2023	Cheshunt / North Pit_Alluvium	11.92	7.7	1132	629	<1	<1	314	314	24	51	199	44	2.0	134	<0.01	< 0.001	<0.05	< 0.0001	< 0.001	< 0.001	< 0.0001	< 0.001	<0.01	<0.005
NPz2	27/09/2023	West Pit_Sandstone/Siltstone	33.02	7.0	13980	8500	< 20	< 20	460	460	780	110	4500	160	21.0	3300	0.3	0.002	0.35	< 0.0002	0.005	< 0.001	< 0.0001	0.014	< 0.001	0.054
PZ2CH400	2/08/2023	Cheshunt / North Pit_Alluvium	8.72	6.9	1438	879	<1	<1	351	351	184	109	215	77	5.0	123	1.3	0.001	0.08	< 0.0001	0.004	< 0.001	<0.0001	0.004	<0.01	0.022
PZ3CH800	2/08/2023	Cheshunt / North Pit_Alluvium	9.22	6.8	2860	1860	<1	<1	582	582	329	225	494	132	5.0	261	0.8	< 0.001	0.06	< 0.0001	0.003	0.007	< 0.0001	0.010	< 0.01	0.033

Additionl analsyses for PZ series of bores:

Bore ID	Date	Geology	Total Antimony (mg/L)	Total Beryllium (mg/L)	Total Cobalt (mg/L)	Total Flouride (mg/L)	Total Iron (mg/L)	Total Manganese (mg/L)	Total Phosphorus as P (mg/L)	Total Rubidium (mg/L)	Total Silicon (mg/L)	Total Strontium (mg/L)	Ammonia as N (mg/L)	Nitrite + Nitrate as N (mg/L)
PZ2CH400	2/08/2023	Cheshunt / North Pit_Alluvium	<0.001	<0.001	0.002	<0.1	4.56	0.00	0.83	0.004	25.80	0.89	1.68	0.13
PZ3CH800	2/08/2023	Cheshunt / North Pit_Alluvium	<0.001	<0.001	0.003	0.10	1.66	0.00	0.33	0.002	31.10	1.80	0.08	0.22

2023 Q4 Comprehensive Water Quality Analysis:

Bore ID	Date	Geology	Depth to Water from Stand Pipe (mbToC)	Field pH (pH unit)	Field Electrical Conductivity (µS/cm)	Total Dissolved Solids (mg/L)	Carbonate Alkalinity as CaCO3 (mg/L)	Hydroxide Alkalinity as CaCO3 (mg/L)	Bicarbonate Alkalinity as CaCO3 (mg/L)	Total Alkalinity as CaCO3 (mg/L)	Sulfate as SO4 (mg/L)	Dissolve d Calcium (mg/L)	Dissolved Chloride (mg/L)	Dissolved Magnesiu m (mg/L)	Dissolved Potassium (mg/L)	Dissolved Sodium (mg/L)	Total Aluminium (mg/L)	Total Arsenic (mg/L)	Total Boron (mg/L)	Total Cadmium (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Mercury (mg/L)	Total Nickel (mg/L)	Total Selenium (mg/L)	Total Zinc (mg/L)
4116P	16/10/2023	North Pit_Spoil	22.26	7.1	11620	7600	< 20	< 20	1000	1000	900.0	170	2900	410	30	1800	1.40	0.018	0.07	0.00020	0.060	0.006	< 0.0001	0.014	0.009	0.120
4119P	26/10/2023	North Pit_Spoil	8.52	6.8	5460	4000	< 20	< 20	900	900	1500.0	170	850	120	21	740	< 0.5	0.130	0.11	< 0.0002	< 0.001	< 0.001	< 0.0001	0.120	< 0.001	0.063
Appleyard Farm	18/10/2023	Lemington South_Alluvium	6.59	6.7	385	240	< 20	< 20	100	100	11.0	11	35	12	4	43	< 0.05	< 0.001	< 0.05	< 0.0002	0.001	< 0.001	< 0.0001	0.001	< 0.001	< 0.005
B425(WDH)	2/11/2023	Lemington South_Woodlands Hill	32.55	7.3	13290	9400	< 20	< 20	930	930	120.0	88	4200	300	28	2200	0.20	0.006	< 0.05	0.00070	0.018	0.009	< 0.0001	0.019	0.025	0.480
B925(BFS)	2/11/2023	Lemington South_Bowfield	60.02	7.0	5050	3000	< 20	< 20	1300	1300	< 2	15	950	15	12	1200	< 0.05	< 0.001	0.11	< 0.0002	0.009	< 0.001	< 0.0001	0.007	< 0.001	0.019
C130(AFS1)	6/11/2023	Lemington South_Arrowfield	18.29	7.3	13000	7900	< 20	< 20	750	750	9.6	100	4300	120	26	2400	0.07	0.004	0.13	< 0.0002	0.003	0.003	< 0.0001	0.004	< 0.001	0.014
C130(ALL)	6/11/2023	Lemington South_Interburden	16.10	6.9	21900	14000	< 20	< 20	940	940	590.0	290	7400	540	39	3100	21.00	0.032	< 0.05	0.04400	0.320	2.900	0.0003	0.130	0.004	0.380
C919(ALL)	6/11/2023	Lemington South_Alluvium	9.11	7.5	670	350	< 20	< 20	280	280	9.2	60	52	31	9	47	28.00	0.009	< 0.05	0.00070	0.100	0.110	0.0002	0.045	< 0.001	0.300
CFW55R	19/10/2023	Carrington_Alluvium	11.05	7.2	3660	2400	< 20	< 20	640	640	290.0	19	670	54	14	670	0.76	0.002	0.11	< 0.0002	0.003	< 0.001	< 0.0001	0.020	0.002	< 0.005
CFW57	20/10/2023	Carrington_Alluvium	11.39	7.5	2090	1200	< 20	< 20	540	540	59.0	32	290	60	3	320	0.18	< 0.001	0.09	< 0.0002	0.001	< 0.001	< 0.0001	0.007	0.003	< 0.005
D010(GM)	2/11/2023	Lemington South_Glen Munro	6.97	6.9	11470	7700	< 20	< 20	1100	1100	250.0	120	3100	330	36	1800	0.23	< 0.001	0.09	< 0.0002	0.004	0.003	< 0.0001	0.027	< 0.001	0.008
DM1	25/10/2023	North Pit_Spoil	24.42	6.6	9820	6600	< 20	< 20	900	900	1600.0	93	2200	460	40	1300	0.07	0.010	0.14	0.00030	0.013	0.001	< 0.0001	0.018	< 0.001	0.065
DM3	25/10/2023	North Pit_Spoil	29.28	6.5	9730	7000	< 20	< 20	850	850	1900.0	210	2300	490	23	1200	0.09	0.013	0.07	< 0.0002	0.001	0.003	< 0.0001	0.044	< 0.001	0.290
DM4	16/10/2023	North Pit_Spoil	15.82	6.9	5800	3900	< 20	< 20	880	880	1100.0	150	950	150	36	1000	0.32	0.420	0.12	< 0.0002	0.006	0.002	< 0.0001	0.006	< 0.001	0.023
DM7	25/10/2023	North Pit_Spoil	31.26	7.5	7030	4300	78.0	< 20	860	940	1400.0	64	1300	220	31	1100	< 0.05	< 0.001	0.09	< 0.0002	< 0.001	0.001	< 0.0001	0.001	< 0.001	0.008
GW-114	26/10/2023	North Pit_Spoil	31.06	6.8	8550	6200	< 20	< 20	840	840	1800.0	160	1800	400	38	1200	0.83	0.014	0.17	0.00020	0.005	0.003	< 0.0001	0.160	< 0.001	0.110
GW-115	26/10/2023	North Pit_Spoil	11.97	6.8	7050	5300	< 20	< 20	820	820	1700.0	180	1200	250	25	1100	< 0.5	0.011	0.14	< 0.0002	< 0.001	< 0.001	< 0.0001	0.080	< 0.001	0.040
LUG Bore	2/11/2023	Lemington South_Mt Arthur	0.00	7.1	8560	4900	< 20	< 20	2600	2600	9.6	26	1400	27	23	2000	< 0.05	0.044	0.15	< 0.0002	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.001	0.006
MB14HVO01	16/10/2023	North Pit_Spoil	32.20	6.8	7310	5200	< 20	< 20	770	770	1600.0	210	1900	260	32	1200	0.06	0.071	0.11	< 0.0002	0.003	< 0.001	< 0.0001	0.058	< 0.001	0.021
MB14HVO02	16/10/2023	North Pit_Spoil	31.85	6.9	7100	4700	< 20	< 20	770	770	1200.0	190	1500	250	32	1100	< 0.05	0.190	0.11	< 0.0002	< 0.001	< 0.001	< 0.0001	0.062	< 0.001	0.019
MB14HVO03	26/10/2023	North Pit_Spoil	31.58	7.0	5450	3800	< 20	< 20	820	820	930.0	160	970	160	24	840	< 0.05	0.200	0.13	< 0.0002	< 0.001	< 0.001	< 0.0001	0.003	< 0.001	< 0.005
MB14HVO04	26/10/2023	North Pit_Spoil	26.41	7.0	5760	4000	< 20	< 20	750	750	1200.0	250	1100	170	20	730	< 0.5	0.110	0.11	< 0.0002	0.002	0.002	< 0.0001	0.048	< 0.001	0.024
MB14HVO05	16/10/2023	North Pit_Spoil	32.44	6.9	7070	5200	< 20	< 20	790	790	1700.0	150	1600	300	42	1100	0.31	0.015	0.09	< 0.0002	0.004	0.001	< 0.0001	0.033	< 0.001	0.150
PB01(ALL)	2/11/2023	Lemington South_Alluvium	8.06	7.2	7740	4100	< 20	< 20	460	460	170.0	53	1200	120	14	750	< 0.05	< 0.001	0.10	< 0.0002	< 0.001	< 0.001	< 0.0001	0.003	0.002	< 0.005
SR007	14/12/2023	Southern_Overburden and Vaux Seam coal	34.29	6.7	7150	5000	< 20	< 20	750	750	640.0	190	1900	370	16	760	< 0.05	< 0.001	< 0.05	< 0.0002	< 0.001	< 0.001	< 0.0001	0.003	< 0.001	< 0.005
SR008	14/12/2023	Southern_Siltstone/sandstone below Lemington Seam	8.87	6.9	14550	9400	< 20	< 20	1200	1200	440.0	120	4300	300	18	2700	< 0.05	< 0.001	0.07	< 0.0002	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.001	< 0.005
SR009	14/12/2023	Southern_Lemington Seam	6.19	7.4	6300	3600	< 20	< 20	850	850	280.0	29	1600	55	9	1300	< 0.05	< 0.001	0.10	< 0.0002	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.001	< 0.005
SR010	14/12/2023	Southern_Conglomerate and Warkworth Seam	10.14	7.2	6190	3500	< 20	< 20	660	660	89.0	96	1600	160	13	970	< 0.05	0.001	0.06	< 0.0002	< 0.001	< 0.001	< 0.0001	0.002	< 0.001	< 0.005
SR011	14/12/2023	Southern_Mt Arthur Seam and underburden	34.25	6.6	16620	12000	< 20	< 20	830	830	390.0	380	5000	630	33	2400	< 0.05	< 0.001	0.08	< 0.0002	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.001	< 0.005
SR012	14/12/2023	Southern Overburden - conglomerate and sandstone	24.67	6.8	13140	7900	< 20	< 20	1100	1100	660.0	180	3700	510	41	2100	< 0.05	< 0.001	< 0.05	< 0.0002	< 0.001	< 0.001	< 0.0001	0.004	0.004	< 0.005





Umwelt (Australia) Pty Limited

T| 1300 793 267 E| <u>info@umwelt.com.au</u>