20 September 2021

Department of Planning, Industry and Environment
Locked Bag 5022
PARRAMATTA NSW 2150
Via Email: Stephen.ODonoghue@planning.nsw.gov.au

Dear Steve,

RE: NARRABRI UNDERGROUND MINE STAGE 3 EXTENSION PROJECT – RESPONSES TO DPIE-WATER SUPPLEMENTARY SUBMISSION

As you are aware, the New South Wales (NSW) Department of Planning, Industry and Environment (DPIE) placed the Narrabri Underground Mine Stage 3 Extension Project (the Stage 3 Project) Environmental Impact Statement on public exhibition in late 2020.

In response to submissions received during the exhibition period, Narrabri Coal Operations Pty Ltd (NCOPL) lodged its Submissions Report on 31 May 2021.

Following this, DPIE-Water has requested further information regarding the Stage 3 Project via a letter on 11 August 2021. A reconciliation of the “prior to determination” matters raised in DPIE-Water’s letter is provided in Table 1. NCOPL would consider the “post-determination” recommendations raised by DPIE-Water following determination of the Stage 3 Project.

NCOPL commissioned WRM Water & Environment (WRM) and Australasian Groundwater and Environmental Consultants (AGE) to assist with the responses. These responses are provided in Attachments 1 and 2, respectively.

Table 1
Reconciliation of DPIE-Water Prior to Determination Matters

No.	DPIE-Water “Prior to Determination” Matter	Response
1	Quantify the annual volume of surface water take due to subsidence related surface fracturing for both the existing and proposed project for a range of climatic scenarios (wet, average, dry) and demonstrate sufficient entitlement can be acquired in the relevant water source to account for the maximum take.	Refer Attachment 1 (report by WRM).
2	Clarify the availability of water entitlement currently used at other mine sites by the proponent, during the period when additional entitlement is required for this project.	Refer below.
3	Clarify the modelled water balance by defining the storage and recharge components, their relationship with each other, and the notation used to present their relative changes, so that their predicted inflows and outflows are not ambiguous.	Refer Attachment 2 (report by AGE).
4	Commit to a date for providing the revised Model Calibration Report to DPIE Water for review as per Recommendation 1 in OUT21/4438.	This was submitted on 20 August 2021.
5	Detail and clarify the methodology applied at groundwater monitoring sites for the early detection of potential subsidence-related impacts including the analytical methodology used for differentiating pore-pressure changes related to subsidence versus other groundwater stressors (climate, third-party land use).	Refer Attachment 2.

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Table 1 (Continued)
Reconciliation of DPIE-Water Prior to Determination Matters

No.	DPIE-Water Matter	Response
6	Provide a field survey to verify the existence, ecological condition, and ecosystem value of any potential high-priority terrestrial GDE located outside the mining leases that are predicted to be potentially impacted by at least 2 m of groundwater drawdown. Some information has been presented on this however it appears to only cover GDEs within the mine lease area.	Refer Attachment 3 (report by Dr Colin Driscoll).
7	For all field verified GDE sites, install site-representative groundwater monitoring infrastructure for inclusion in the monitoring program and establish appropriate make good provisions.	As per the draft groundwater monitoring program provided to DPIE via letter dated 21 July 2021, NCOPL would undertake regular (i.e. annual) site observations of flow rates and surface conditions of potential groundwater features including Hardys, Mayfield and Eather Springs, and Blairmore Features 1 and 2.

Response to Item 2

Table 2 provides a summary of Whitehaven's existing Water Access Licences in the *Gunnedah-Oxley Based MDB Groundwater Source* and the predicted operational take in 2040, which is the year of the Stage 3 Project's maximum predicted take.

Table 2 indicates that, during the period of the maximum Stage 3 Project predicted take in the *Gunnedah-Oxley Basin MDB Groundwater Source*, Whitehaven would have a surplus of approximately 1,763 units across its operations. Therefore, Whitehaven has excess entitlements in this groundwater source across its operations which would be transferred and used for the Stage 3 Project.

In addition, this groundwater source is significantly under-allocated and has had several controlled allocation periods of interest between 2017 and 2020. Most recently, the Controlled Allocation Order (Various Groundwater Sources) 2020 offered 4,043 shares of the *Gunnedah-Oxley Basin MDB Groundwater Source*.

Table 2
Whitehaven's Gunnedah-Oxley Basin MDB Groundwater Source Water Access Licences

Site	Approved Mine Life	Water Access Licence	Allocation (ML)	Predicted Operational Take in 2040 (Narrabri Max Predicted Take Year)	Available Allocation Surplus
Narrabri Mine	2031	29549	818	2,406[1]	-
		43017	403		
Werris Creek Mine	2032[2]	32224	211	-	
		29506	50		
Sunnyside Mine	2020[3]	29537	120	-	
Canyon Mine	2015[4]	29548	50	-	
Maules Creek Mine	2034[5]	29467	306	-	
		36641	800		
Rocglen Mine	2022[6]	29461	120	-	
		36758	700		
Tarrawonga Mine	2030[7]	31084	250	-	
Vickery Mine	2045[8]	36576	600	259[9]	
Whitehaven (total)		-	4,428	2,665	**1,763**

1 AGE (2020) *Groundwater Assessment – Narrabri Underground Mine Stage 3 Extension Project*.
2 As per Project Approval 10_0059.
3 As per Project Approval 06_0308.
4 As per DA 8-1-2005.
5 As per Project Approval 10_0138.
6 As per Project Approval 10_0015.
7 As per Project Approval 11_0047.
8 As per SSD 7480.
9 HydroSimulations (2018) *Vickery Extension Project Groundwater Assessment*.

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Please do not hesitate to contact the undersigned on 6794 4184, 0448 045 814 or DEllwood@whitehavencoal.com.au should you have any queries.

Yours sincerely,

David Ellwood
Director NCO Stage 3 Project

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ATTACHMENT 1

WRM WATER & ENVIRONMENT RESPONSE TO DPIE-WATER MATTERS

Memorandum

Date	17 September 2021	Pages	10
Attention	Mark Vile		
Company	Narrabri Coal Operations Pty Ltd		
Job No.	0189-13-L1		
Subject	Narrabri Underground Mine Stage 3 Extension Project (SSD-10269) Response to DPIE and NRAR Information request		

Dear Mark,

I refer to the letter from Mr Mitchell Isaacs of the Department of Planning, Industry and Environment - Water (DPIE-Water) dated 11 August 2021 regarding the request for additional information to estimate the water take associated with surface cracking due to mine subsidence at the Narrabri Mine. In particular, DPIE-Water has requested to:

> *Quantify the annual volume of surface water take due to subsidence related surface fracturing for both the existing and proposed project for a range of climatic scenarios (wet, average, dry) and demonstrate sufficient entitlement can be acquired in the relevant water source to account for the maximum take.*

Outlined below is an estimate of the quantity of the maximum annual volume of water take based on:

- advice on the expected crack dimensions from Ditton Geotechnical Services (DGS);
- an assessment of the surface runoff volume that could accumulate in each crack; and
- an assessment of the frequency of surface runoff that could be captured between crack rehabilitation works.

It has been assumed that the Narrabri Coal Operations Pty Ltd (NCOPL) Procedure for Subsidence Monitoring and Management of LW107 - LW110 dated April 2020 will be updated to incorporate the Stage 3 Extension Project area. This document states that surface cracking will be monitored monthly and following rain events and remediation measures will be implemented when surface cracks exceed 50 mm. These remediation measures may include "*ripping of surface cracks, filling of cracks with grout, subsoil from reject emplacement area, gas drainage or ventilation sites, or other self cementing material*."

For the purpose of this assessment, based on advice from NCOPL, it has been assumed that cracks would be remediated within six-months of its development and the cracks would no longer capture surface runoff once remediated.

Ditton Geotechnical Services Advice

DGS provided a spreadsheet of the expected crack volumes around each Stage 3 longwall panel (LW203 to LW210) (see Figure 1). Volumes were provided for the maximum period between crack repair, which was advised by NCOPL to be six months. A copy of the DGS spreadsheet is given in Table 1.

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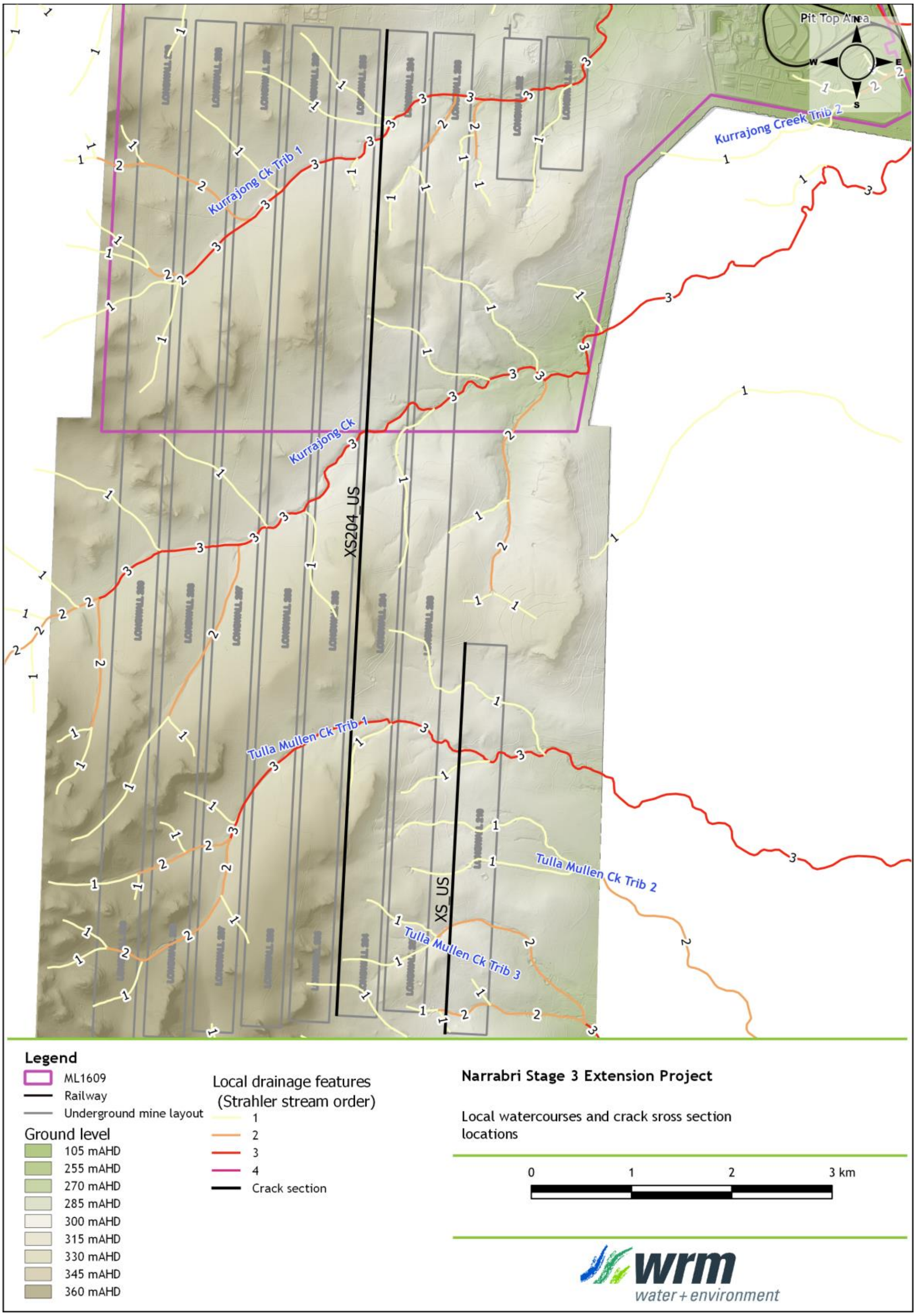

Figure 1 – Narrabri Stage 3 layout and drainage characteristics

Table 1 – DGS spreadsheet of crack volumes[1]

	Crack Volumes							Predicted		Predicted Open		6-monthly		m3	m3	ML	ML	Average	Average
LW	XL	W	H	W/H	s	Emax		Crack Width (mm)		Crack Depth (m)		Crack Length (m)		Vol1	Vol2	Vol1	Vol2	width(mm)	Vol (ML)
203	6	402.9	214	1.88	11	15	29	315	630	1.5	2.5	4406	4406	1040.9	3469.6	1.0	3.5	473	2.08
	7	402.9	207	1.95	10	15	31	320	640	1.5	2.5	4406	4406	1057.4	3524.6	1.1	3.5	480	2.11
	8	402.9	199	2.02	10	17	33	330	661	1.5	2.5	4406	4406	1090.4	3640.3	1.1	3.6	496	2.18
	9	402.9	224	1.8	11	14	27	304	608	1.5	2.5	4406	4406	1004.5	3348.4	1.0	3.3	456	2.01
	10	402.9	220	1.83	11	14	28	310	620	1.5	2.5	4406	4406	1024.3	3414.5	1.0	3.4	465	2.05
204	6	402.4	238	1.69	12	12	24	286	573	1.5	2.5	4405	4405	944.8	3154.9	0.9	3.2	430	1.89
	7	402.4	244	1.65	12	11	23	279	559	1.5	2.5	4405	4405	921.7	3077.9	0.9	3.1	419	1.85
	8	402.4	222	1.81	11	14	27	303	605	1.5	2.5	4405	4405	1001.0	3331.1	1.0	3.3	454	2.00
	9	402.4	247	1.63	12	11	22	276	552	1.5	2.5	4405	4405	911.8	3039.3	0.9	3.0	414	1.82
	10	402.4	260	1.55	13	10	20	262	524	1.5	2.5	4405	4405	865.5	2885.1	0.9	2.9	393	1.73
205	6	399.7	263	1.52	13	10	20	259	519	1.5	2.5	4399	4399	854.6	2854.1	0.9	2.9	389	1.71
	7	399.7	280	1.43	14	9	17	244	487	1.5	2.5	4399	4399	805.1	2678.1	0.8	2.7	366	1.61
	8	399.7	250	1.6	13	11	22	273	545	1.5	2.5	4399	4399	900.8	2997.1	0.9	3.0	409	1.80
	9	399.7	278	1.44	14	9	18	245	491	1.5	2.5	4399	4399	808.4	2700.1	0.8	2.7	368	1.62
	10	399.7	289	1.38	14	8	16	236	472	1.5	2.5	4399	4399	778.7	2595.6	0.8	2.6	354	1.56
206	6	399.7	297	1.35	15	8	15	230	459	1.5	2.5	4399	4399	758.9	2524.2	0.8	2.5	345	1.52
	7	399.7	312	1.28	16	7	14	219	437	1.5	2.5	4399	4399	722.6	2403.2	0.7	2.4	328	1.44
	8	399.7	285	1.4	14	8	17	239	478	1.5	2.5	4399	4399	788.6	2628.6	0.8	2.6	359	1.58
	9	399.7	304	1.31	15	7	15	224	449	1.5	2.5	4399	4399	739.1	2469.2	0.7	2.5	337	1.48
	10	399.7	305	1.31	15	7	15	224	447	1.5	2.5	4399	4399	739.1	2458.2	0.7	2.5	336	1.48
207	6	402.2	330	1.22	17	6	13	207	413	1.5	2.5	4404	4404	683.8	2273.8	0.7	2.3	310	1.37
	7	402.2	318	1.26	16	7	13	214	429	1.5	2.5	4404	4404	706.9	2361.9	0.7	2.4	322	1.42
	8	402.2	320	1.26	16	7	13	213	426	1.5	2.5	4404	4404	703.6	2345.3	0.7	2.3	320	1.41
	9	402.2	321	1.25	16	7	13	212	425	1.5	2.5	4404	4404	700.3	2339.8	0.7	2.3	319	1.40
	10	402.2	319	1.26	16	7	13	214	427	1.5	2.5	4404	4404	706.9	2350.8	0.7	2.4	321	1.41
208	6	401.2	352	1.14	18	6	12	215	429	1.5	2.5	4402	4402	709.9	2360.8	0.7	2.4	322	1.42
	7	401.2	323	1.24	16	7	13	211	422	1.5	2.5	4402	4402	696.7	2322.3	0.7	2.3	317	1.39
	8	401.2	346	1.16	17	6	12	211	422	1.5	2.5	4402	4402	696.7	2322.3	0.7	2.3	317	1.39
	9	401.2	340	1.18	17	6	12	207	415	1.5	2.5	4402	4402	683.5	2283.7	0.7	2.3	311	1.37
	10	401.2	356	1.13	18	6	12	217	434	1.5	2.5	4402	4402	716.5	2388.3	0.7	2.4	326	1.43
209	6	356.7	365	0.98	18	7	15	274	547	1.5	2.5	4313	4313	886.4	2949.3	0.9	2.9	411	1.77
	7	356.7	346	1.03	17	7	15	256	512	1.5	2.5	4313	4313	828.2	2760.6	0.8	2.8	384	1.66
	8	356.7	380	0.94	19	8	15	286	571	1.5	2.5	4313	4313	925.2	3078.7	0.9	3.1	429	1.85
	9	356.7	376	0.95	19	7	15	282	563	1.5	2.5	4313	4313	912.3	3035.6	0.9	3.0	423	1.82
	10	356.7	400	0.89	20	8	15	304	608	1.5	2.5	4313	4313	983.5	3278.2	1.0	3.3	456	1.97
210	9	415.4	184	2.26	10	19	37	374	748	1.5	2.5	4431	4431	1242.8	4142.8	1.2	4.1	561	2.49
	10	415.4	180	2.31	10	20	39	391	781	1.5	2.5	4431	4431	1299.3	4325.6	1.3	4.3	586	2.60
	min	356.7	180	0.89	10	6	12	207	413						LW203-209	min	max		
	max	415.4	400	2.31	20	20	39	391	781							0.68	3.64	ML	
	mean	396	289	1.44	14	10	19	261	522						mean	0.84	2.79	1.81	1.67
																min	max		
															LW210	1.2	4.3	ML	
															mean	1.27	4.23	2.75	2.54

[1] XL – cross line; W – width; H – cover depth; Emax - strain

DGS advised that the estimates of cracking over the proposed longwalls assumes a single crack will effectively form around the perimeter of the longwall extraction limits for the period between crack rehabilitation works (i.e. 6 months). DGS consider that this approach is reasonable for estimating surface runoff losses due to increased infiltration rates and assumes groups of cracks may be represented by a single crack. Crack dimension measurements above LW104 to 109 have been referred to.

The volume of 'open' cracks above 6-months of retreat before rehabilitation work is completed above the proposed longwalls has been estimated based on the following equation:

Open Crack Volume = (crack width x crack depth x crack length)/2

Where:

- the crack width is predicted to range from 207 mm to 781 mm (allowing for side wall slumping and based on predicted strains of 6 mm/m to 39 mm/m (decreasing from LW203/210 to 209) multiplied by Cover Depth/20.
- the crack depth is assumed to be an 'open depth' that allows for side wall slumping and ranges between 1.5 m and 2.5 m. Note: DGS advises that the true crack depth of say 5 m to 10 m is not considered applicable for making estimates of rainfall infiltration rate 'increases'. Because of the tapered geometry of the cracks, the effective volume is negligible at these 5 – 10 m depths.
- crack length = 2*(longwall retreat over 6 months + panel void width). The average monthly retreat rate for LW107 to 109 ranged from 165 m to 180 m / month, but this is expected to increase to 300 m per month for Stage 3.

The results of the assessment are as follows:

- Open crack volumes for LW203 to 209 range from 0.68 ML to 3.64 ML (average of 1.81 ML) over 6-months
- Open crack volumes for LW210 ranges from 1.2 ML to 4. 3 ML (average of 2.75 ML) over 6-months

Water capture volume in each crack

Given the surface topography, any surface runoff that enters a surface crack would not accumulate along the full extent of the open crack estimated by DGS because it would flow downslope along the crack and overflow at the lowest point, usually a watercourse. The catchment area and therefore surface runoff draining to the surface cracks away from each watercourse is also much lower than where water accumulates at a watercourse.

Figure 1 shows the Project area and the watercourses which traverse the area. Stream order for these watercourses is also shown.

Figure 2 and Figure 3 show cross sections at the expected crack locations along the upstream (western) side of LW210 and LW204. The locations of the cross sections are shown in Figure 1. LW210 was selected because it is located along the flattest section of the mining area (allowing more ponding within the crack) and also has the widest cracks identified by DGS (see Table 1). LW204 was selected because it crosses each of the third order watercourses.

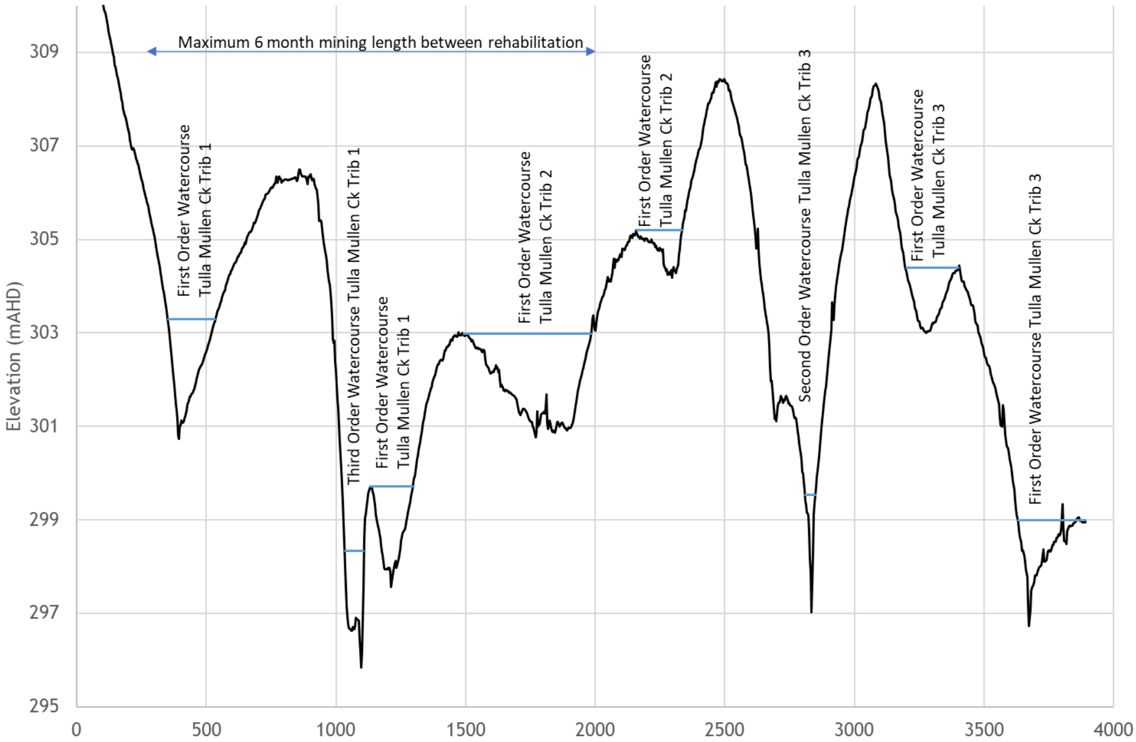

Figure 2 – Cross section along the upstream side of LW210

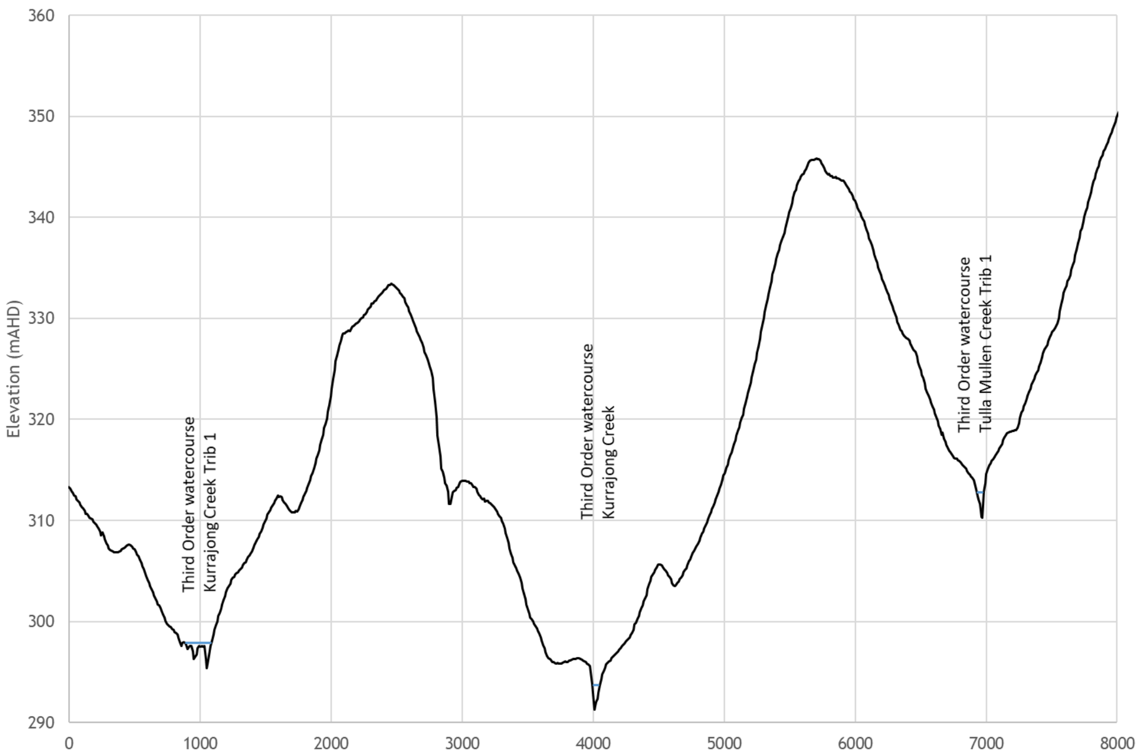

Figure 3 – Cross section along the upstream side of LW204

The cross sections also show the extent of the ponding within each crack assuming the maximum predicted crack depth of 2.5 m, as suggested by DGS. It is expected that surface runoff draining into the crack would flow downslope along the crack to pond at each lowest point, generally a watercourse.

For the crack upstream of LW210, water would pond at:

- two Tulla Mullen Creek Trib 1 tributaries (first order watercourses)
- Tulla Mullen Creek Trib 1 (third order watercourse)
- two Tulla Mullen Creek Trib 2 tributaries (first order watercourses)
- Tulla Mullen Creek Trib 3 (second order watercourse) and
- two Tulla Mullen Creek Trib 3 tributaries (first order watercourses)

The greatest extent of open cracking over the six month rehabilitation period would be over the first 2,000 m of the LW210 cross section shown in Figure 2. Rehabilitation of the first ponding location would have occurred before subsidence and cracking would occur at the next waterway crossing. The depth of ponding at most of the first order watercourses along LW210 would not reach the maximum depth of 2.5 m, as predicted by DGS, because it would overflow downslope along the crack to another watercourse. The maximum possible width of ponding to the overflow point is shown in blue on Figure 2.

For the crack upstream of LW204, water would pond at each of the three third order watercourses:

- Kurrajong Creek Trib 1
- Kurrajong Creek and
- Tulla Mullen Creek Trib 1

For LW204, ponding would only occur at one third order watercourse at a time because rehabilitation works would have occurred prior to reaching the next third order watercourse due to the expected mining rate. The maximum possible width of ponding to the overflow point is shown in blue on Figure 3.

Table 2 shows the estimated ponding lengths along the cracks for the sections shown in Figure 2 and Figure 3, separated into the estimated ponding above first/second order watercourses and third order watercourses. The maximum water capture volume between the six month rehabilitation periods for each cross section is also shown.

Table 2 – Estimated maximum capture volume in surface cracks

Crack location	Crack ponding length (m)			Max crack width (mm)	Water capture volume (m^3)		
	1st/2nd order	3rd order	Total		1st/2nd order	3rd order	Total
XS210_US	896	180	1,075	781	874	175	1,050
XS204_US	0	186[a]	186	620	0	144	144
Maximum					874	175	1,050

[a] Maximum ponding length occurs over Kurrajong Creek Trib 1 (Figure 3)

The capture volume was determined using the same methodology adopted by DGS by conservatively assuming each crack length ponded to a depth of 2.5 m (i.e. Open Crack Volume = [crack width x crack depth x crack length]/2).

Assuming the same capture volume occurs on the crack on the other side of the longwall panel, the maximum capture volume between each six month rehabilitation period would be:

- 1,749 m^3 or 1.75 ML for the first/second order watercourses;
- 350 m^3 or 0.35 ML for the third order watercourses; and
- A total of 2,100 m^3 or 2.1 ML from all watercourses.

It is understood that a Water Licence issued under the *Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012* (NPURWS) (Eulah Creek Water Source) may be required for the take from the third order watercourses and the harvestable right defined in the *Water Management Act 2000* (WM Act) may be used for the take from the first and second order watercourses.

Surface runoff capture volume

The volume of surface runoff capture in the surface cracks would depend on:

- the frequency of runoff,
- the infiltration rate, and
- the ability of the cracks to self-repair following a runoff event.

Frequency of runoff

The sandy upper catchment soils associated with the Pilliga Sandstone as well as the sandy upper horizon soils in the lower catchment suggests that the frequency of surface runoff is low to very low. This is consistent with site observations where long periods of no runoff are frequent. For this reason alone, the lower end capture volume estimate would be zero.

Infiltration rates

There is no data on the infiltration rates for the lower horizon soils that cross the mine subsidence zones. However, the subsurface soil types were determined by GT Environmental (2020) for the Agricultural Impact Statement prepared for the EIS (Appendix G). Of the 20 test pits that were excavated (to depths of 1.2 m), five were taken along waterways (adjacent to Tulla Mullen Creek Trib 1 and Trib 3). Of the five, four of the subsoils were classified as medium clays.

Based on Rawles et al (1983), the saturated hydraulic conductivity of a medium clay is about 0.5 mm/hr (12 mm/day). At this rate, it would take 208 days for the water ponded in the crack to infiltrate. That is, the cracks could not be filled twice over the six months maintenance period.

Self-repair of cracks

The capability of the cracks to self-repair will depend upon the expected soil erosion that would occur due to surface runoff as well as erosion within the cracks. The capability would be expected to be higher along the drainage lines as it receives surface runoff from the largest upstream catchment area.

Given the sandy nature of the upstream catchment, it is expected that the cracks will self-repair along the waterways at least to a certain extent following each runoff event. Although the sediment volumes have not been calculated for this assessment, it has been conservatively assumed that the cracks adjacent to the waterways would fill with sediment after two runoff events.

Water licensing considerations

The Project is located wholly within the Eulah Creek water source within the NPUWSP.

For the predicted surface water take within first/second order watercourses (up to 3.5 ML/annum) (i.e. assuming the cracks could be filled twice between each six month rehabilitation period), it is understood that NCOPL may rely on its harvestable right entitlement for Project water storages (subject to incorporation in the Water Management Plan). Under the WM Act, landholders in rural areas are permitted to collect a proportion of the rainfall runoff on their property and store it in one or more dams up to a certain size on minor streams. A dam can capture up to 10% of the average regional rainfall runoff for their landholding without requiring a licence.

According to the WaterNSW calculator, the maximum harvestable right for the Project area is 0.065 ML per ha. The landholding area required for the purposes of the harvestable right calculation is the NCOPL's contiguous landholding which is 8,723.6 ha. Based on the NCOPL's contiguous landholding and the harvestable rights multiplier value of 0.065 ML/ha for the relevant area, the total harvestable right for the Project is 567 ML.

For the rest of the take (i.e. from third order watercourses), estimated at up to 0.7 ML/annum, NCOPL would obtain a suitable license within the NPUWSP (Eulah Creek water source) prior to any take occurring from this source. It is noted that water is traded within this source from time-to-time (14 units were transferred in the water year 2019-20[2]).

Monitoring

The average annual runoff volume from each of the local catchments draining the Narrabri Mine is expected to exceed 2,800 ML and therefore the predicted maximum capture volume of the surface cracks is negligible. It is also unlikely to be directly measurable. A very accurate and reliable stream gauge would be required to predict a change in runoff volumes, which is not practical for the local waterways for the following reasons:

- The establishment of a reliable stage discharge relationship (rating curve) for the site would require frequent stream gauging. It is not practical or possible to engage a skilled hydrographer that is local and can attend site and measure the flows given the short duration and infrequent nature of the flow events.
- The monitoring of stream water levels from a waterway with a mobile sandy bed is generally unreliable, as small shifts in sand can change the flow depths for each flow event. This means that regular stream gauging would be required to ensure the low flow rating curve is up to date and reliable.

[2] https://waterregister.waternsw.com.au/water-register-frame.

- The broad, ill-defined flows mean that a very small increase in water level of 0.1 m to 0.2 m will lead to a significant increase in flow rate, which means that a significant number of gaugings across all flow rates would be required to make the rating reliable. There are an insufficient number of flow events in any year for this to physically occur.

To overcome these reliability issues, a low flow control weir would be required to both provide reliable water level and stream flow estimates from each watercourse. It is not practical to establish a weir in the third order watercourses given the volume of sediment and the broad and erosive nature of the existing channels. Notwithstanding, it is recommended that NCOPL engages a suitably qualified hydrologist to review the estimate provided in this memo on a regular basis. The review would include:

- identification of the crack dimensions and locations;
- a review of the remediation measures and remediation frequency; and
- an assessment of the frequency and intensity of rainfall events between remediation periods.

Summary of findings

The maximum annual volume of water take from the surface cracks has been estimated based on advice from DGS on the expected crack dimensions and an assessment of the drainage characteristics of each crack due to topographic changes. Two sample cross sections were used in the analysis representing the maximum that would occur for the Stage 3 Project. However, the analysis is expected to be similar across the existing mining areas.

In summary, the maximum annual take of water from the surface cracks conservatively assuming the cracks could be filled twice between each six month rehabilitation period, would be:

- 3,500 m^3 or 3.5 ML for the first/second order watercourses;
- 700 m^3 or 0.7 ML for the third order watercourses; and
- A total of 4,200 m^3 or 4.2 ML from all watercourses.

The minimum take would be zero given that no surface runoff can occur within the six month maintenance period.

Given that expected average annual runoff volume from each of the local catchments is expected to exceed 2,800 ML, the capture volume is negligible. It is also unlikely to be directly measurable. Notwithstanding, it is recommended that NCOPL engages a suitably qualified hydrologist to review the estimate provided in this memo on a regular basis.

For and on behalf of
WRM Water & Environment Pty Ltd

Greg Roads
Director

References:

GT Environmental (2020)	*'Land Resource Assessment for the Narrabri Underground Mine Stage 3 Extension Project'* prepared for Narrabri Coal Operations Pty ltd by GT Environmental, August 2020.
Rawls, W, J, Brakesiek & Miller, N, 1983	*'Green-Ampt infiltration parameters from soils data'*, Journal of Hydraulic Engineering, vol 109, 62-71

ATTACHMENT 2

AGE RESPONSE TO DPIE-WATER MATTERS

Memorandum

Project number	G1972
To	Mark Vile
Company	Narrabri Coal Operations Pty Ltd
From	Keith Phillipson
Date	20 September 2021

RE: Narrabri Stage 3 Extension Project Groundwater Assessment Response to DPIE Water Supplementary Submission dated 11 August 2021

1 Introduction

Narrabri Coal Operations Pty Ltd (NCOPL), has requested that AGE provide a response to three DPIE-Water submissions included in their letter dated 11 August 2021, provided below in Sections 1.1, 1.2, 1.3. Section 2 of this memo provides a suggested response to each submission for incorporation in the final NCOPL response.

1.1 Submission 1

The terminology and expression applied in the presentation of the modelled water balance results, especially regarding groundwater storage, are ambiguous and require clarification. The proponent describes storage inputs which the readers might assume to refer to increased storage water in the aquifer, but alternatively might mean water release from storage. Accordingly, the water balance as presented cannot be verified against rainfall conditions.

…

Clarify the modelled water balance by defining the storage and recharge components, their relationship with each other, and the notation used to present their relative changes, so that their predicted inflows and outflows are not ambiguous.

1.2 Submission 2

The Aquifer Interference Policy 2012 specifies that any change in groundwater quality should not lower the beneficial use category of a groundwater source. The term "beneficial use category" is described in the NSW Groundwater Quality Protection Policy 1998 as being equivalent to the term "environmental value" in the national water quality guidelines, since superseded by "community value" in the current ANZ Guidelines for Fresh and Marine Water Quality (2018).

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Accordingly, the proponent is required under the Aquifer Interference Policy 2012 to apply the current national water quality guidelines to identify, validate, monitor, and report on water-quality indicators that are relevant to stakeholder-agreed community values.

All community values are susceptible to a variety of physical and chemical stressors and toxicants which cannot be indicated by salinity alone. The status of additional key water-quality indicators must therefore be reported on.

1.3 Submission 3

Detail and clarify the methodology applied at groundwater monitoring sites for the early detection of potential subsidence-related impacts including the analytical methodology used for differentiating pore-pressure changes related to subsidence versus other groundwater stressors (climate, third-party land use).

2 Submission responses

2.1 Submission 1

Appendix D of the Narrabri Underground Mine Stage 3 Extension Project Groundwater Assessment Report (Australasian Groundwater and Environmental Consultants Pty Ltd [AGE], 2020, referred to hereafter as the GA Report)[1] includes the following table (Table D 3.11 reproduced here as Table 1) which summarises inflows and outflows to the MODFLOW groundwater flow modelling tool developed for the assessment. As shown in Table 1 results are presented for a steady state calculation, which relates to the pre-mining period, and averages for the transient calibration period which runs from January 2009 to June 2019. Time series of each water balance component summarised in Table 1 are also shown in Figure 2.1.

When interpreting the time series chart and table it is important to note that the MODFLOW modelled Storage IN water balance term represents water that is being released from storage and hence represents an inflow to the model. As shown in Figure 2.1, Storage IN therefore increases during dry periods when rainfall recharge is zero and releases from storage to essentially support ongoing outflows from the model (i.e. baseflow to rivers and groundwater extraction from Narrabri Mine and water supply wells). This leads to declining groundwater levels in the simulation as the amount of water held in storage reduces.

Conversely the modelled Storage OUT water balance term represents water that is entering storage and hence is effectively leaving the simulation (albeit temporarily) and entering the groundwater store. As shown in Figure 2.1 Storage OUT therefore increases during wet periods when rainfall recharge is relatively high and excess water, over and above the other ongoing water demands, enters storage. This in turn leads to increasing groundwater levels in the simulation as the amount of water held in storage increases.

As summarised in Table 1 over the modelled calibration period from January 2009 to June 2019 the average of the storage IN values (57.8 ML/day) exceeds the average of the storage OUT values (49.9 ML/day) (i.e. the volume of water being released from storage and entering the simulation slightly exceeds the volume of water leaving the simulation entering storage). This is consistent with the lower than average rainfall conditions which have prevailed for much of the calibration period, particularly in the period since early 2012. Hence, as shown in Figure 2.1 the periods in which modelled recharge is occurring and water is entering storage (i.e. storage_OUT is also elevated) are separated by long periods when water being released from storage (i.e. storage_IN is elevated) to support ongoing outflows (predominantly extraction from water supply wells and discharge to surface water courses).

[1] AGE, 2020, Groundwater Assessment – Narrabri Underground Mine Stage 3 Extension Project, Final Report, October 2020 (https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021150.054%20GMT).

Table 1 Modelled water balance (ML/day)

Water balance component	Steady state model			Transient model average		
	in	out	in – out	in	out	in - out
Storage	-	-	-	57.8	49.9	7.9
Rainfall recharge	90.2	0.0	90.2	90.9	0.0	90.9
River (minor watercourses)	0.0	4.5	-4.5	0.0	6.1	-6.1
Stream (major watercourses)	10.8	44.8	-34.0	10.3	47.7	-37.4
Evapotranspiration	0	2.6	-2.6	0.0	3.2	-3.2
General head boundary	23.1	12.7	10.4	24.0	13.8	10.2
Wells	0	59.5	-59.5	0.0	61.3	-61.3
Drains (mine inflows)	0	0	0.0	0.0	1.0	-1.0
Total	**124.2**	**124.2**	**0.0**	**183.0**	**183.0**	**0.0**

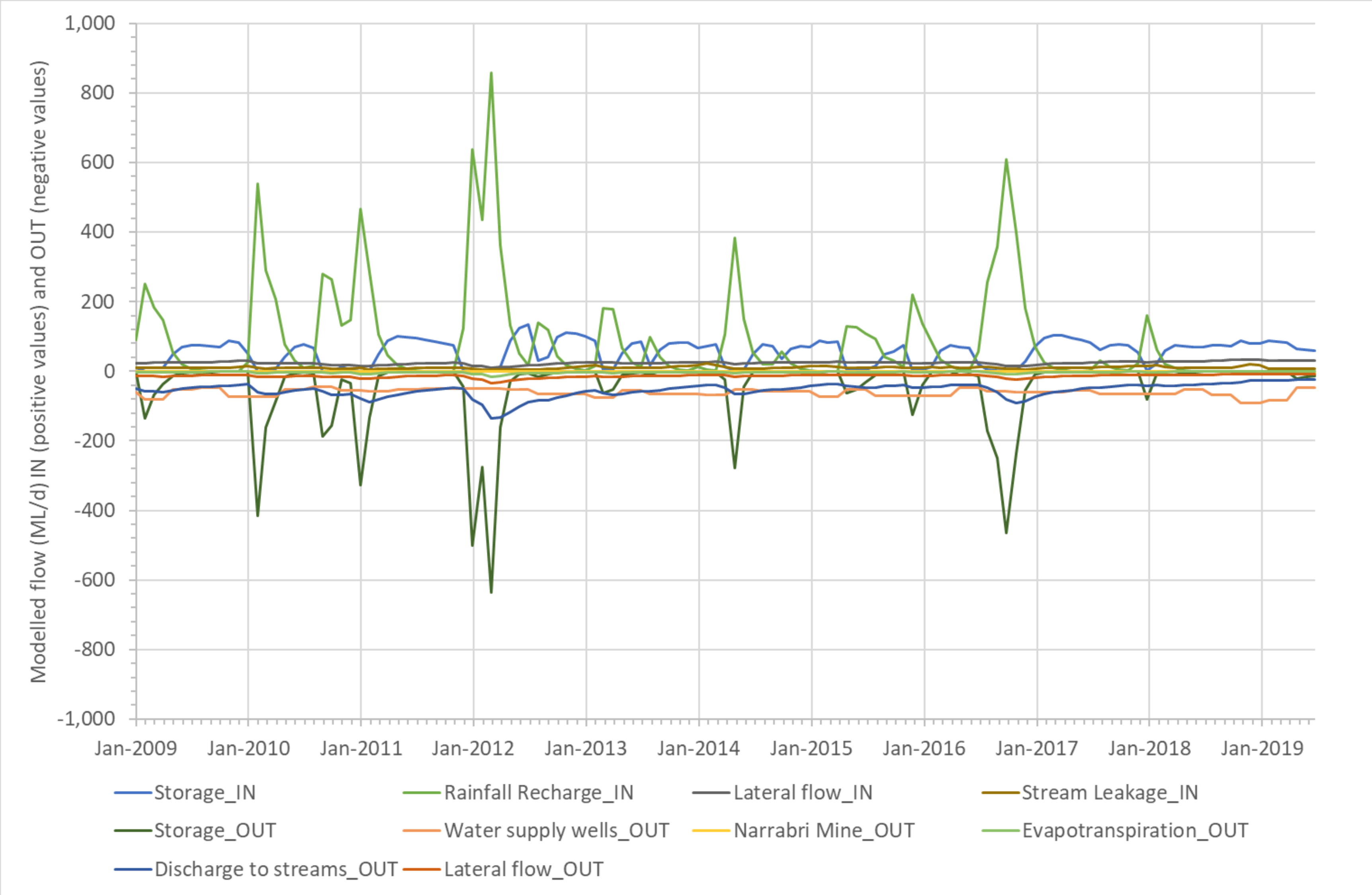

Figure 2.1 Water balance time series January 2009 to June 2019

2.2 Submission 2

The status of a range of key water quality indicators at the Narrabri Mine including field pH, field EC, a number of metals and metalloids (including aluminium, arsenic, cobolt, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc), major cations and anions (i.e. calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulphate and chloride), ammonia and nitrate are currently reported annually in a series of environmental audit reports[2]. These reports also provide a summary of environmental performance over the preceding year in relation to groundwater inflows, groundwater levels and groundwater quality and compare observed groundwater quality and groundwater levels to triggers defined in the current site Extraction and Mine Water Management Plans (Whitehaven, 2017[3]; Whitehaven, 2020[4]). A revised version of the current Mine Water Management Plan (Whitehaven, 2020) to address regulator comments is currently being prepared and already includes trigger values for a range of key water quality indicators to protect existing environmental values. This document will be further revised following approval of the Stage 3 Extension Project.

2.3 Submission 3

Early warning of groundwater level impacts will also be provided by annual environmental audit reports which will include a comparison of observed groundwater levels at Narrabri Mine monitoring network bores with trigger levels defined in the Mine Water Management Plan. As mentioned previously a revised version of the current Mine Water Management Plan (Whitehaven, 2020) to address regulator comments is currently in preparation which includes time varying triggers based on the predicted drawdown at each monitoring point. Since predictions of the magnitude and extent of subsidence and longwall induced fracturing are encapsulated in these drawdown predictions then early warning of larger than expected groundwater level impacts will be provided by trigger level exceedance. Where groundwater level triggers are exceeded, then this will result in additional investigations as defined in the Trigger Action Response Plan (TARP). For groundwater level trigger exceedances then, as outlined in the current TARP, a suitably qualified hydrogeologist would be engaged to conduct an assessment. The primary aim of this assessment would be to assess if the trigger exceedance is related to mining activities. Since the scope of this assessment will depend on the nature of the exceedances then it is not possible to confirm the detail of the analytical methodology which would be most applicable, at this time. However, the assessment would include collation or consideration of the following data sets:

- groundwater quality and level records both for the mine monitoring network and other local monitoring bores (where relevant);
- surface water quality and level or flow records for the mine monitoring network;
- updated local climate data;
- mine inflow volumes and water quality data;
- mine subsidence monitoring data; and
- available information on other local activities which might influence groundwater levels (other resource extraction activities, landholder bore operations etc).

These data sets would then be reviewed to confirm whether or not the observed exceedances are likely to be related to operation of the Narrabri Mine and/or other external factors (climate, other local activities etc). Where necessary, the existing Project Groundwater Flow Model (AGE, 2020) could then be used to further quantify the contribution of difference sources of impact. Where trigger exceedances appeared to be related to subsidence impacts, then the existing numerical model could be re-run with updated climate data and revised parameterisation of fracture zones above the mine to quantify the contribution of these two stresses to the observed drawdown.

The data collation, review and assessment process described above will also be included in the Project Water Management Plan, to be submitted separately following approval of the Stage 3 Extension Project.

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[2] https://whitehavencoal.com.au/Documentations/Narrabri%20Mine/Environmental%20Management,%20Monitoring%20&%20Compliance/Annual%20Reviews/NAR-Annual%20Review%202019.pdf

[3] Whitehaven, 2017, Narrabri Mine, Extraction Plan Water Management Plan LW107 to LW110.

[4] Whitehaven, 2020, Narrabri Mine Environmental Management System, Water Management Plan.

ATTACHMENT 3

GROUNDWATER FEATURES OF INTEREST FIELD ASSESSMENT

HUNTER ECO

Whitehaven Coal Limited
10 Kurrajong Creek Rd
BAAN BAA NSW 2390

Attention: Mark Vile

16 October 2020

Dear Mark

Narrabri - Water Sharing Plan Updates and High Priority GDEs – Field Assessment

Background and Methods
Water Sharing Plans within the modelled groundwater drawdown extent for the Narrabri Stage 3 Extension Project have been updated to include a number of High Priority Groundwater-Dependent Ecosystems (GDEs), mapped as high potential GDEs in the Bureau of Meteorology (BoM) Groundwater Dependent Ecosystem Atlas (GDE Atlas) (BoM 2020). The GDE Atlas nominates specific vegetation community types for these areas drawn from the Border Rivers Gwydir / Namoi Regional Native Vegetation Mapping (BRGN, Office of Environment and Heritage [OEH] 2015).

The OEH (2015) vegetation mapping was achieved through a combination of modelling and field data collection. A field inspection of the relevant GDE Atlas high potential GDE vegetation communities was conducted on 30th and 31st July 2020 in order to verify the Plant Community Type (PCT) and possible groundwater dependency. The dominant flora species were recorded along with the geographic location and soil observations where accessibility permitted. High resolution telephoto photography was also used to assess some inaccessible areas.

The technical publication describing the process of assigning groundwater dependency to New South Wales vegetation is found in Doody *et al.* (2017). A number of variables were combined to arrive at the three classes of GDE mapped in the GDE Atlas: High Potential; Moderate Potential and Low Potential. The main components used were: Inflow Dependent Ecosystems; Depth to Water Table; Soil Water Holding Capacity; and Eco-hydrogeological Zones. Of these Depth to Water Table and Soil Water Holding Capacity were available to assist in assessing groundwater dependency of the target vegetation. It is generally accepted that Depth to Water Table of less than 10 metres (m) is within the root depth range of a number of species. Access to groundwater is also related to Soil Water Holding Capacity such that groundwater under sandy soils having low Soil Water Holding Capacity is more likely to be accessed by roots than groundwater under clay soils (such as cracking clays) having high Soil Water Holding Capacity where plants would access retained soil moisture.

There are two types of GDE: ecosystems that are dependent in whole or in part on water reserves held in the ground; and those dependent on the surface expression of groundwater. Water reserves held in the ground form the saturated part of the aquifer soil matrix that sits below the 'water table' or 'phreatic surface', and are differentiated from water bound in the soil matrix in the unsaturated zone above the water table. Water in the soil aquifers originates from all or any of: rainfall directly on the aquifer surface; runoff from areas immediately adjacent to the aquifer; or sub-surface inflow. The quantity of rainfall that stays in the unsaturated zone and the quantity that makes it into the water reserves is a function of unsaturated zone soil moisture dynamics.

Vegetation making up a GDE, termed phreatophytic and consisting of phreatophytes, can have varying degrees of dependency on the groundwater. Obligate GDEs are made up of species that depend entirely on the groundwater and are capable of living with their roots continually wet or at least for seasonal periods of inundation. Facultative GDEs contain species that access the groundwater via the capillary fringe and also take up water from within the soil matrix above this area (Hatton and Evans 1998). These plants cannot cope with having their roots inundated with water.

Results

Floristic content and other characteristics were recorded at 49 locations and Attachment 1 shows these on maps of the target vegetation split into target areas to allow for tabulating the variation found during the field survey where the same predicted community had different actual composition. Attachment 2 provides a table of the overall results. Attachment 3 shows images typical of the PCTs.

In the north of the study area (Target Area 1) (Attachment 2) (Plates 1 and 2) a community modelled as *Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest* contained Dirty Gum (*Eucalyptus chloroclada*) and Carbeen (*Corymbia tessellaris*) in place of Narrow-leaved Ironbark. This community was on a low sand dune with average depth to water of approximately 5-10 mbgl (Australasian Groundwater and Environmental Consultants [AGE] 2020). Sand has a low water holding capacity meaning that it is possible that the main canopy trees need to access the underlying groundwater in periods when the sandy soil moisture is insufficient. Thus, this is potentially a facultative GDE.

The area surrounding the sand dune (Target Areas 5 and 6) (Attachment 2) (Plate 3) is lower-lying cracking clay (Vertosols) in cleared grazing land with numerous paddock trees, generally Poplar Box (*Eucalyptus populnea* subsp. *bimbil*) along with Pilliga box (*Eucalyptus pilligaensis*). Along roadside strips (Target Area 2) (Attachment 2) White Cypress Pine (*Callitris glaucophylla*) and Buloke (*Allocasuarina luehmannii*) were also present. While depth to water is between approximately 2.5 and 13.6 mbgl (AGE 2020) in these areas, the cracking clay soils have a high water-holding capacity and Doody *et al.* (2017) note that vegetation associated with cracking clay is unlikely to be groundwater-dependent.

In the south of the study area all target communities (Target Areas 7-17, 19, 21, 24 and 28) (Attachment 2) (Plates 4-12) were located along ephemeral creeklines, primarily Tulla Mullen Creek, Sandy Creek, Little Sandy Creek and an unnamed creek. The vegetation along these creeks was variously mapped by BRGN as containing River Red Gum (*Eucalyptus camaldulensis*) or generic Red Gums with tea tree in a forested wetland community; field inspection showed there were no River Red Gums, tea tree or wetlands. Red Gums were present in the form of Forest Red Gum (*Eucalyptus tereticornis*) or Blakely’s Red Gum (*Eucalyptus blakelyi*) along with Rough-barked Apple (*Angophora floribunda*) and these were generally restricted to the stream bank. Away from the stream edge the vegetation became dry, dominated by White Cypress Pine with areas including Narrow-leaved Ironbark. The stream beds were wide and sandy with little vegetation. The narrow stream edge vegetation is likely to be a facultative GDE with shallow root systems accessing both stream bed water and adjoining soil water.

In both the north and south of the study area *Shallow freshwater wetland sedgeland* (Target Areas 23, 24 and 26) (Attachment 2) was modelled along some streamlines in predominantly cleared paddocks. These areas were not all accessible but from what could be seen they appeared to be overgrown with weeds and grasses. Small patches of habitat consistent with *Shallow freshwater wetland sedgeland* were recorded along the unnamed creek (Target Area 28) (Attachment 1) (Plate 12) where there was intermittent ponding and surrounding wet areas supporting sedges and grasses. The sedge community was not particularly diverse being dominated by *Eleocharis plana* and *Juncus sarophorus*. Weeds recorded were the grass *Arrhenatherum bulbosum*, and herbs *Ornithopus compressus* and *Sisyrinchium iridifolium*. The average fall along that stretch of the creek was only 0.23 degrees, which facilitates stormwater retention (ponding) in local sink areas. Depth to the underlying groundwater was between approximately 3 and 4 mbgl (AGE 2020) and the soil type was Vertosols, having high water holding capacity which would limit hydraulic connection from the water table to the surface. The surrounding canopy trees would be facultative in their requirements, mostly utilising retained soil moisture.

Target Area 28 was inspected in more detail on 21st and 22nd September 2020 to assess whether the sedge areas were GDEs. On a broad scale it was discovered that there was a network of berms through the area along with dam walls that resulted in artificial impounded water areas that did support sedgeland in the shallower reaches (Figure 3; Plates 13, 14, 15). It was concluded that these were dammed waters not connected to underlying groundwater. Further upstream there were areas of sedge habitat immediately below a large dam wall and it was concluded that these were the result of seepage through the wall.

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Only one area had a natural eroded pond with sedge vegetation downstream. The soil profile was sampled by auger at two locations (Plate 16) to a depth of approximately one metre. In both cases there was a dense damp clay layer to approximately 0.8 m below which the soil became more granular and porous. No plant roots extended below the clay layer and no water seeped into the auger holes, even overnight.

The physical evidence indicates that the bulk of the sedge habitat is supported by impounded water either in the shallow reaches or from seepage through dam walls. The naturally ponded area is clearly isolated from the underlying groundwater by a high water-holding capacity clay layer with root depth not extending below the clay layer. This habitat would not be affected by any groundwater drawdown from the underground mine.

Yours Faithfully
HUNTER ECO

Colin Driscoll

Dr Colin Driscoll
Environmental Biologist

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References

Australasian Groundwater and Environmental Consultants (2020) *Narrabri Underground Mine Stage 3 Extension Project – Groundwater Impact Assessment.* Prepared for Narrabri Coal Operations Pty Ltd.

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Office of Environment and Heritage (2015). Border Rivers Gwydir / Namoi Regional Native Vegetation Mapping. Technical Notes, New South Wales Office of Environment and Heritage, Sydney, Australia.

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ATTACHMENT 1 FIGURES

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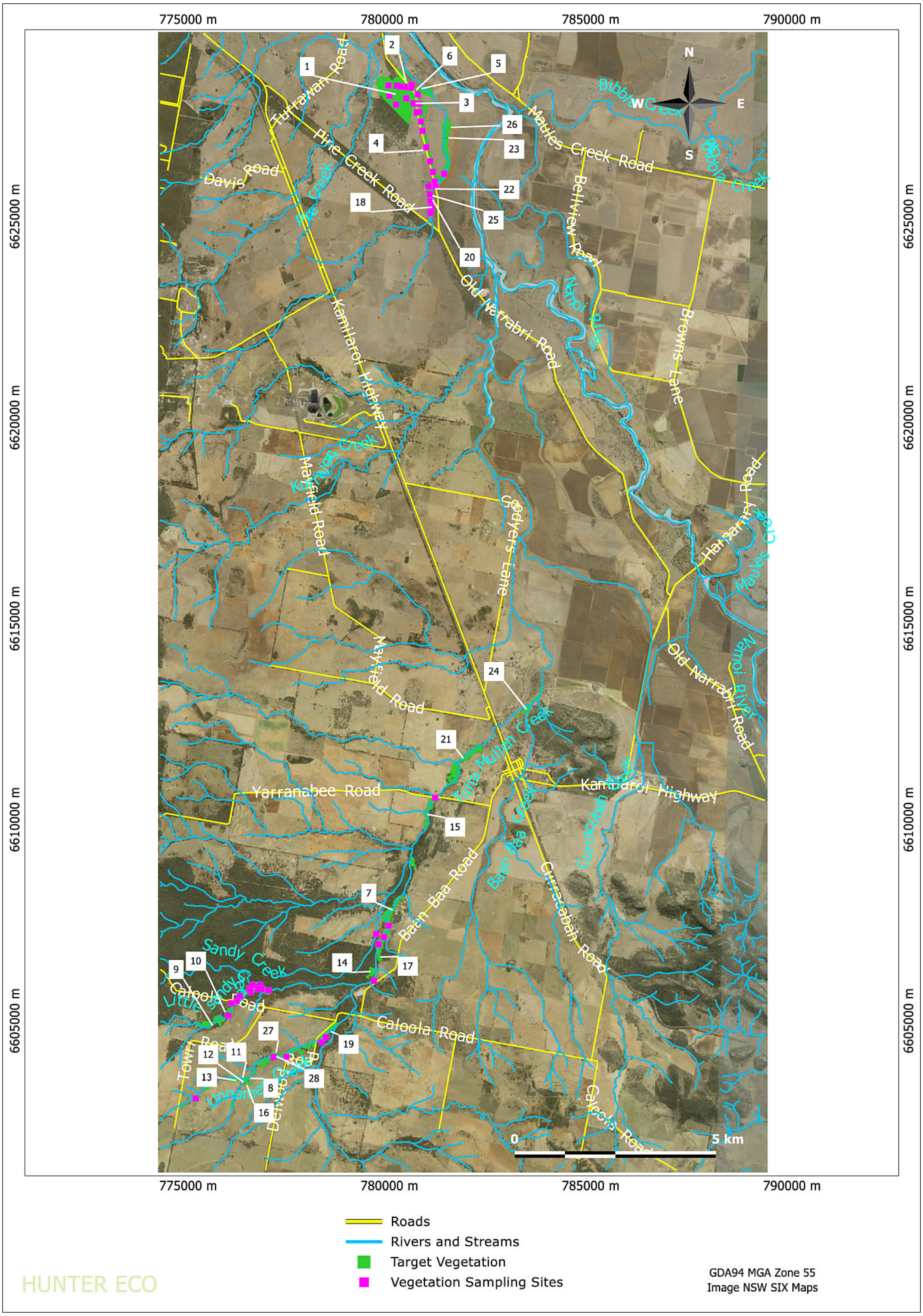

Figure 1 Map of the Target Vegetation

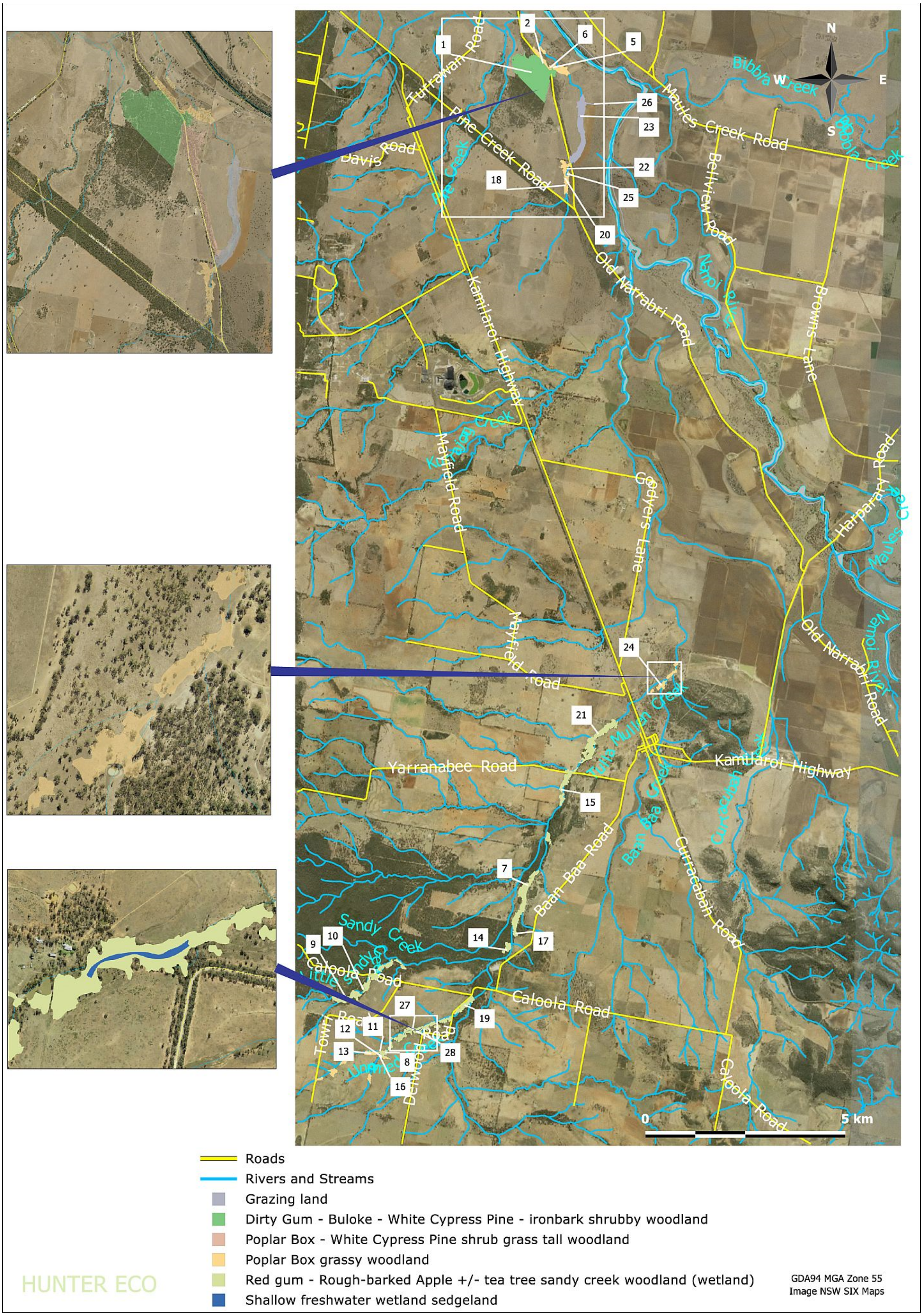

Figure 2 Map of the Ground-truthed Vegetation

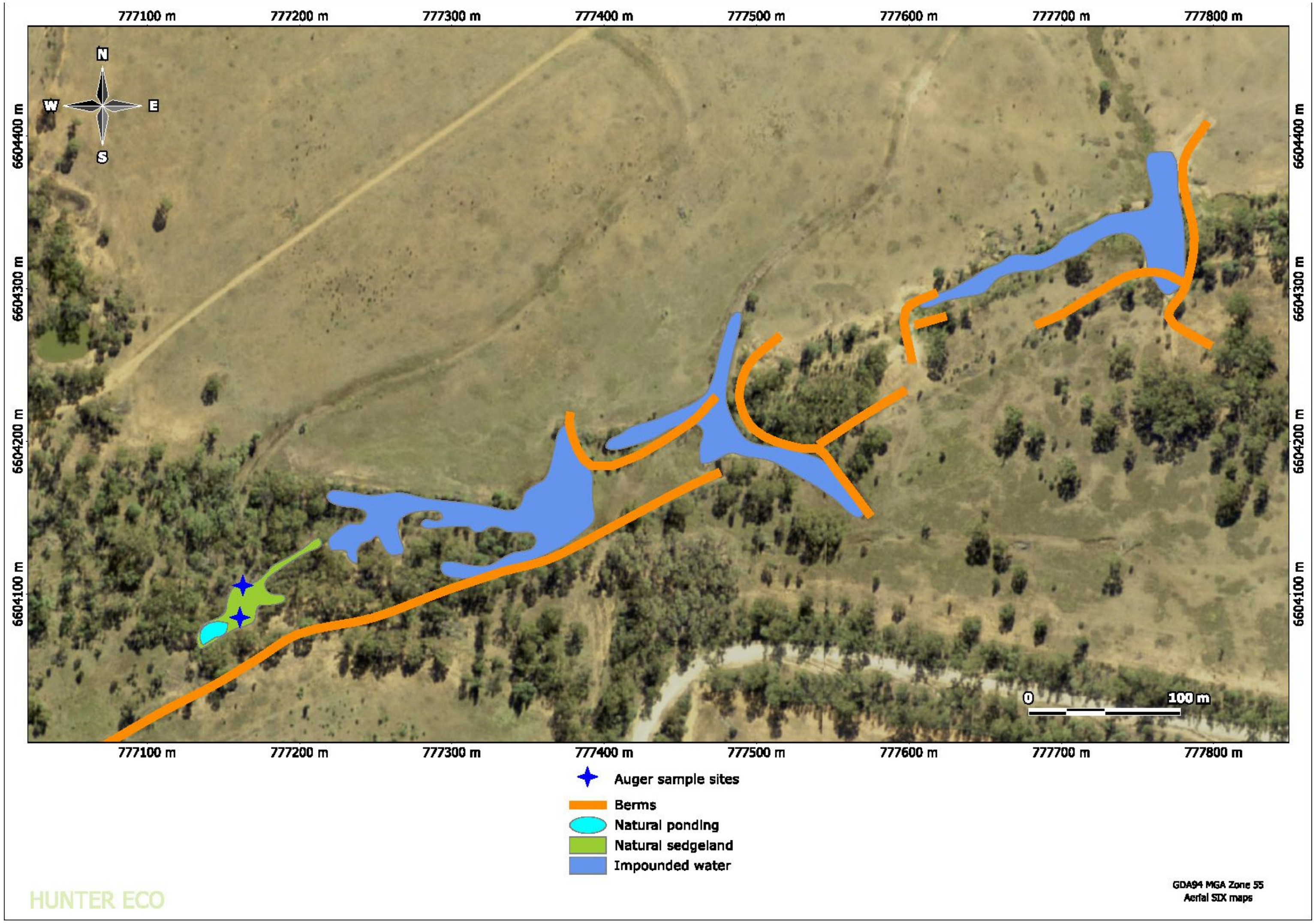

Figure 3 Map of the Structure of the Sedgeland Areas at Site 28

ATTACHMENT 2 FIELD SURVEY RESULTS

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Target Area	BoM (2020) Community	PCT (Field)	PCT Name	Observations	Soil Type	GDE Assessment	Depth to Water Table (m) Pre-mining	Drawdown (m)	Depth to Water Table (m) Post-mining
1	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	148	Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	No Narrow-leaved Ironbark. Dominant *Eucalyptus chloroclada*, some *Corymbia tessellaris. Callitris glaucophylla*, *Allocasuarina luehmannii*.	Sodosols	Moderate probability facultative GDE being on deep sand having low soil water holding capacity.	10	1	11
2	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	148	Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	No Narrow-leaved Ironbark. Dominant *Eucalyptus chloroclada*, some *Corymbia tessellaris. Callitris glaucophylla*, *Allocasuarina luehmannii*.	Vertosols	Moderate probability facultative GDE being on deep sand having low soil water holding capacity.	10	1	11
5	Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No Yellow Box, Western Grey box. Mix of Poplar Box and occasional Pilliga Box.	Sodosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	9	1	10
6	Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No Yellow Box, Western Grey box. Mix of Poplar Box and occasional Pilliga Box.	Vertosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	9	0	9
7	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	7	1	8
8	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's	Vertosols	Narrow facultative GDE restricted to stream bank.	7	3	10

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Target Area	BoM (2020) Community	PCT (Field)	PCT Name	Observations	Soil Type	GDE Assessment	Depth to Water Table (m) Pre-mining	Drawdown (m)	Depth to Water Table (m) Post-mining
	forests, Brigalow Belt South Bioregion		sandstone forests, Brigalow Belt South Bioregion	Red Gum restricted to stream bank.					
9	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	7	2	9
10	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	7	3	10
11	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	7	4	11
12	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No tea tree. Not a wetland. Wide sandy stream bed. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	7	0	7
13	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No Red Gums, Rough-barked Apple, tea tree. Mostly Poplar Box with some Pilliga Box and White Cypress Pine.	Sodosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	7	4	11
14	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Chromosols	Narrow facultative GDE restricted to stream bank.	4	0	4

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Target Area	BoM (2020) Community	PCT (Field)	PCT Name	Observations	Soil Type	GDE Assessment	Depth to Water Table (m) Pre-mining	Drawdown (m)	Depth to Water Table (m) Post-mining
			sandstone forests, Brigalow Belt South Bioregion						
15	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	4	1	5
16	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	4	3	7
17	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Sodosols	Narrow facultative GDE restricted to stream bank.	4	0	4
18	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No River Red Gums. Poplar Box dominant.	Sodosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	5	8	13
19	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Vertosols	Narrow facultative GDE restricted to stream bank.	4	1	5
20	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No River Red Gums. Poplar Box dominant.	Vertosols	Low probability GDE due to high soil water holding capacity.	5	7	12

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Target Area	BoM (2020) Community	PCT (Field)	PCT Name	Observations	Soil Type	GDE Assessment	Depth to Water Table (m) Pre-mining	Drawdown (m)	Depth to Water Table (m) Post-mining
						Probably cracking clays.			
21	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Vertosols	Narrow facultative GDE restricted to stream bank.	4	1	5
22	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No wetland, sedgeland.	Sodosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	5	5	10
23	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Drainage line, mostly grassy, weedy.	Sodosols	Not GDE vegetation.	4	3	7
24	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Not inspected. Google Earth image does not indicate freshwater wetland. Flow into the area is interrupted by a dam.	Vertosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	9	0	9
25	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	No wetland, sedgeland.	Vertosols	Low probability GDE due to high soil water holding capacity. Probably cracking clays.	5	6	11
26	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Drainage line, mostly grassy, weedy.	Vertosols	Not GDE vegetation.	4	1	5

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Target Area	BoM (2020) Community	PCT (Field)	PCT Name	Observations	Soil Type	GDE Assessment	Depth to Water Table (m) Pre-mining	Drawdown (m)	Depth to Water Table (m) Post-mining
27	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	399	Red Gum – Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga – Goonoo sandstone forests, Brigalow Belt South Bioregion	No River Red Gums. Red Gums, Forest Red Gum, Blakely's Red Gum restricted to stream bank.	Vertosols	Narrow facultative GDE restricted to stream bank.	4	1	5
28	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Small patches of habitat consistent with Shallow freshwater wetland sedgeland were recorded along a section of the unnamed creek where there was intermittent ponding and surrounding wet areas supporting sedges and grasses.	Vertosols	Not GDE vegetation.	4	1	5

Note: Highlighted cells are assessed GDEs.

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ATTACHMENT 3 VEGETATION IMAGES

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Plate 1 Dirty Gum and White Cypress Pine on Sand (PCT 148) at Target Area 1

Plate 2 Carbeen and White Cypress Pine on a Low Sand Dune (PCT 148) at Target Area 1

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Plate 3 Poplar Box on Cracking Clay (PCT 244, 397) at Target Area 6

Plate 4 Tulla Mullen Creek (PCT 399) at Target Area 7

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Plate 5 Red Gum, Forest Red Gum and Blakely's Red Gum Along Tulla Mullen Creek (PCT 399) at Target Area 7

Plate 6 Red Gum, Forest Red Gum and Blakely's Red Gum Along Tulla Mullen Creek (PCT 399) at Target Area 7

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Plate 7 Little Sandy Creek (PCT 399) at Target Area 8

Plate 8 Poplar Box with some Pilliga Box and White Cypress Pine (PCT 244) at Target Area 13

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Plate 9 Blakely's Red Gum (PCT 399) at Target Area 19

Plate 10 Little Sandy Creek (PCT 399) at Target Area 19

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Plate 11 Little Sandy Creek (PCT 399) at Target Area 19


Plate 12 Possible Sedgeland Community (PCT 53) Underneath Canopy of PCT 399 at Target Area 28

Plate 13 Impounded Water with Bordering Sedge Habitat

Plate 14 Impounded Water with Bordering Sedge Habitat

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Plate 15 Sedge Habitat Immediately Below a Dam Wall


Plate 16 Auger Sampling in the Natural Sedgeland Area

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