PEMBROKE

Olive Downs Coking Coal Project

Additional Information to the Environmental Impact Statement

Section 5

Response to IESC Advice

5 RESPONSE TO IESC ADVICE

1. Provide a stand-alone response to the IESC advice. Address the key areas identified by the IESC where additional information is required, including the following:

a) Undertake additional baseline ecological surveys

Pembroke understands that this comment relates to baseline ecological surveys for stygofauna.

Stygofauna surveys were conducted in accordance with the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITIA, 2015). A desktop review was undertaken considering the suitability of local geological and hydrological conditions for stygofauna and presence of stygofauna based on previous studies. The results of the desktop review are provided in Section 5.10.1 of the Aquatic Ecology Assessment prepared by DPM Envirosciences (Appendix C of the draft EIS). Stygofauna sampling was undertaken. No stygofauna were identified during sampling (as stated in Section 4.1 of the draft EIS).

All suitable bores (two) were sampled. HydroSimulations (Appendix D of the draft EIS) incorporated slot widths of 1.5 mm into the screened interval of these bores so that they are also suitable for stygofauna sampling (Appendix C of the draft EIS). Although the number of bores dipped (two) was lower than the preferred number described in the guidelines (10), this limitation is acknowledged in the recently released IESC *Information Guidelines Explanatory Note: Assessing Groundwater-Dependent Ecosystems* (IESC, 2019):

> *… stygofauna surveys usually rely on access to an already existing bore network, which limits where samples can be collected and the number of suitable bores available for each aquifer type.*

Notwithstanding, the EIS conservatively assumes that stygofauna could potentially occur in the unconsolidated sediments (alluvium) associated with the Isaac River and the potential impacts on stygofauna were addressed in the draft EIS. The *Aquatic Ecology Assessment* prepared by DPM Envirosciences (Appendix C of the draft EIS) states:

> *An assessment is provided here assuming that stygofauna are present within the unconsolidated sediments (alluvium).*
>
> *The Project would directly intercept groundwater from the unconsolidated sediments (alluvium) and sub-artesian aquifers which could provide potential habitat for stygofauna as identified by 4T (2012). Given this, the Project is expected to result in a drawdown in the unconsolidated sediments associated with the Isaac River of no more than 5 m, predominantly adjacent to the Olive Downs South Domain (HydroSimulations 2018). Drawdown in the unconsolidated sediments adjacent the Willunga Domain would also be less than 5 m and would only occur in a small portion of the alluvium associated with the Isaac River (HydroSimulations 2018).*
>
> *As indicated by HydroSimulations (2018), the alluvium is not limited to the Project area and appears to be saturated along the Isaac River and lower reaches of the creeks at the confluence with the Isaac River (HydroSimulations 2018). This indicates that the potential habitat for stygofauna (if they were to occur) is much more extensive than the alluvium within the area of influence associated with the Project. Given the extent of the alluvium along the Isaac River, it is considered unlikely that the Project would result in a significant impact to any stygofauna community (if they were to occur).*

Further, as detailed in Appendix E, Figure 5-5 of the Groundwater Assessment (Appendix D of the draft EIS), indicates that the saturated thickness of the alluvium along the Isaac River is up to 35 m. Accordingly, the maximum predicted drawdown within the Isaac River alluvium (5 m) is not expected to dewater the alluvial aquifer.

b) Update the numerical groundwater modelling once additional data have been collected

Each year, an annual review of groundwater level trends would be conducted by a suitably qualified person. The review would assess the change in groundwater levels over the year, compared to historical trends and impact assessment predictions.

As stated on Page 3-161 of the draft EIS, the validity of the groundwater model predictions would be assessed and, if the data indicates significant divergence from the model predictions, the groundwater model would be updated for simulation of mining.

Pembroke proposes a network of reference and compliance bores be included in the EA Conditions for the Project, including proposed new monitoring locations to add to existing baseline datasets. The Stage 1 reference and compliance bores are listed in Table 5-1 and shown on Figure 5-1. As stated on Page 4-86 of the draft EIS, recording of groundwater levels from existing monitoring bores and VWPs would continue and would enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from proposed mining activities. Since lodgement of the draft EIS, groundwater monitoring has continued, and updated groundwater quality data has been included in Section 13.

Pembroke's approach is consistent with the IESC's suggestion. If after two years after installation of additional monitoring bores there is a significant deviation from the model predictions identified, then the model would be subject to review. The review process would involve re-running the groundwater model, confirming the revised predictions, undertaking any additional consultation deemed necessary and adjusting the proposed control measures as required.

Table 5-1
Groundwater Monitoring Locations and Frequency - Stage 1 Mining Operations

Monitoring Point	Location		Surface RL (m AHD)[1]	Monitoring Frequency
	Easting	Northing		
Reference Bores[2]				
GW22	640193*	7547639*	182.00	Q
GW23	646895*	7537007*	169.09	D/Q
GW24	648450*	7533805*	166.00	D/Q
GW25	640345*	7540008*	185.97	D/Q
GW26	639307*	7538727*	192.71	D/Q
GW27	639465*	7535303*	178.00	D/Q
GW28	642729*	7533536*	172.01	D/Q
RN158484	648152	7524058	160.00	D/Q
GW01s	642481	7547491	180.65	D/Q
GW02s	641152	7546517	179.11	D/Q
GW02d	641141	7546507	179.11	D/Q
GW04	643388	7544973	178.23	D/Q
GW06s	639329	7542005	191.77	D/Q
GW08s	645312	7539839	172.27	D/Q
GW12s	641504	7532788	175.84	D/Q
S11	642455	7545332	178.45	D/Q
S8	642340	7546343	177.84	D/Q
S4	641567	7546845	178.85	D/Q
S5	642239	7547332	179.26	D/Q
S2	641386	7547617	176.97	D/Q

Table 5-1 (Continued)
Groundwater Monitoring Locations and Frequency - Stage 1 Mining Operations

Monitoring Point	Location		Surface RL (m AHD)[1]	Monitoring Frequency
GW01d (VWP1, VWP2, VWP3, VWP4)	642479	7547491	181.58	D
GW06d (VWP1, VWP2, VWP3, VWP4)	639334	7542008	192.86	D
GW08d (VWP1, VWP2, VWP3, VWP4)	645312	7539846	172.18	D
GW12d (VWP1, VWP2, VWP3, VWP4)	641495	7532795	176.89	D
Bore 8[3]	640186	7547990	188.00	Q
Swamp Bore[3]	645595	7528661	171.00	Q
RN122458 (Rolfies #2)[3]	644971	7526779	174.00	Q
RN122458 (Rolfies #1)[3]	644973	7526776	172.00	Q
Compliance Bores				
GW22	640193*	7547639*	182.00	Q
GW23	646895*	7537007*	169.09	D/Q
GW24	648450*	7533805*	166.00	D/Q
GW26	639307*	7538727*	192.71	D/Q
GW27	639465*	7535303*	178.00	D/Q
GW01s	642481	7547491	180.65	D/Q
GW21s	661590	7521656	162.07	D/Q
GW21d	661585	7521655	162.09	D/Q
GW01d (VWP1, VWP2, VWP3, VWP4)	642479	7547491	181.58	D
GW06d (VWP1, VWP2, VWP3, VWP4)	639334	7542008	192.86	D
GW12d (VWP1, VWP2, VWP3, VWP4)	641495	7532795	176.89	D
Bore 8[3]	640186	7547990	188.00	Q
Swamp Bore[3]	645595	7528661	171.00	Q
RN122458 (Rolfies #2)[3]	644971	7526779	174.00	Q
RN122458 (Rolfies #1)[3]	644973	7526776	172.00	Q

Monitoring is not required where a bore has been removed as a direct result of the mining activity.

* Approximate location only, to be confirmed.

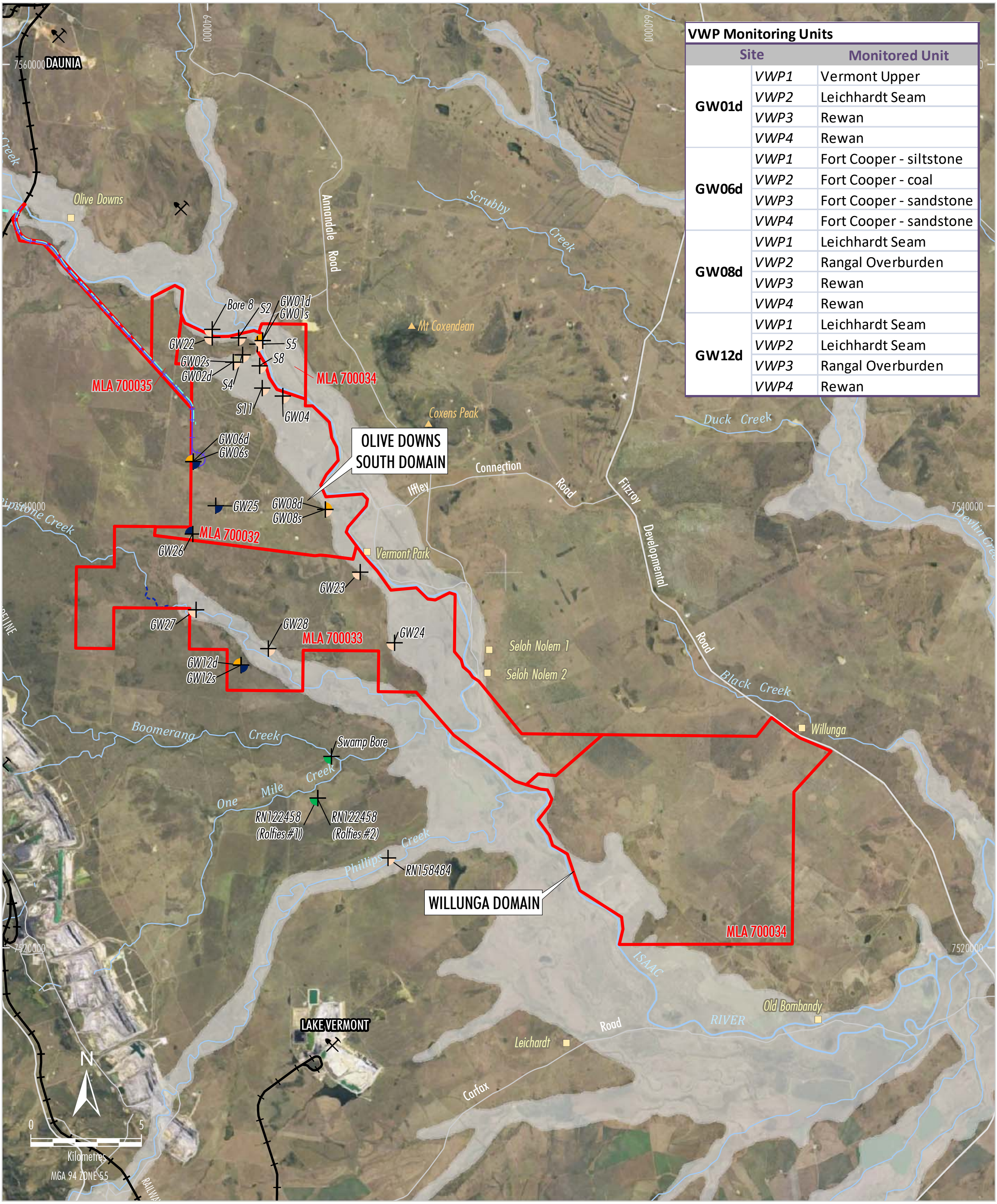
1. RL must be measured to the nearest 5cm from the top of the bore casing.
2. Reference sites must: (a) have a similar flow regime (b) be from the same bio-geographic and climatic region (c) have similar geology, soil types and topography (d) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.
3. Subject to landholder access.

D = Daily monitoring frequency using automatic logger.

Q = Quarterly monitoring frequency (i.e. dipped and sampled).

D/Q = Daily monitoring frequency using automatic logger and manually dipped and sampled on a quarterly basis.

Since lodgement of the draft EIS in July 2018 (which included data up to February 2018), Pembroke has continued to collect groundwater quality data from the groundwater monitoring network which has been established across the Project area. Groundwater quality sampling events were conducted in April, June, July, August and November 2018. Groundwater sampling events were conducted at bores GW01s, GW02d, GW02s, GW04, GW06s, GW08s, GW12s, GW16s, GW18d, GW18s, GW21d and GW21s (Figure 5-1). This additional baseline water quality data is provided at the end of this section.



VWP Monitoring Units

Site		Monitored Unit
GW01d	VWP1	Vermont Upper
	VWP2	Leichhardt Seam
	VWP3	Rewan
	VWP4	Rewan
GW06d	VWP1	Fort Cooper - siltstone
	VWP2	Fort Cooper - coal
	VWP3	Fort Cooper - sandstone
	VWP4	Fort Cooper - sandstone
GW08d	VWP1	Leichhardt Seam
	VWP2	Rangal Overburden
	VWP3	Rewan
	VWP4	Rewan
GW12d	VWP1	Leichhardt Seam
	VWP2	Leichhardt Seam
	VWP3	Rangal Overburden
	VWP4	Rewan

LEGEND

- Mining Lease Application Boundary
- Railway
- Dwelling
- Proposed Rail Spur and Loop
- Proposed Water Pipeline
- Proposed Creek Diversion

Standpipe

Compliance and Reference Bore (Monitored Unit)

- Alluvium
- Permian
- Regolith

Reference Bore (Monitored Unit)

- Alluvium
- Regolith
- Vermont Upper

VWP

- Compliance and Reference Bore*
- Reference Bore*

** Please refer to the "VWP Monitoring Unit" table for the monitored units.*

Source: Pembroke (2018), Geoscience Australia - Topographical Data 250K (2006), Department of Natural Resources and Mines (2016)
Orthophotography: Google Image (2016)

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Stage 1 - Groundwater Monitoring Sites

Figure 5-1

Note: The quadrant coloured within each symbol indicates whether the bore would be used as a Compliance and Reference Bore or as only a Reference Bore.

c) provide additional information on the predicted quality of untreated discharge water and associated impacts of both intentional and unintentional releases

Sediment dams (for settling of solids with residence time) are a primary water treatment process. Controlled releases from sediment dams are not considered to be 'untreated' discharges. Importantly it should be recognised that when releases do occur, the mine water management system has been designed to preferentially ensure that runoff from largely disturbed areas do not (where practicable) report to a dam that is then used for discharge.

Sediment dam water quality is generally expected to be of better quality than mine water dams. This is operational risk management in practice. In rainfall events below the design standard, runoff from disturbed areas would be intercepted and treated by sediment dams. In larger events that exceed the design standards, these dams would overflow following a period of settlement treatment. Available geochemical information (Appendix L of the draft EIS) indicates that the runoff draining to the sediment dams should have low salinity.

Overflows would only occur during significant rainfall events which would also generate runoff from surrounding undisturbed catchments. Hence it is unlikely that sediment dam overflows would have a measurable impact on receiving water quality or environmental values (Appendix E of the draft EIS).

Nevertheless, the REMP process is acknowledged, and Pembroke has committed to monitoring runoff reporting to sediment dams to validate the relevant predictions and assumptions. Surface runoff and seepage from waste rock emplacements, including any rehabilitated areas, would be monitored for ‘standard’ water quality parameters including, but not limited to, pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

The sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams and haul road runoff dams. Initially, the sediment dam monitoring would occur on a regular (e.g. monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam monitoring would be reviewed and updated accordingly (e.g. to occur only when releases occur).

The water quality parameters proposed to be monitored have been outlined in the draft EIS (as above) and will be included in the REMP. It is anticipated the monitoring requirements as part of the REMP will be stipulated in the EA Conditions (as per the draft EA Conditions F20 and F21 in Appendix B).

d) undertake further assessment of groundwater-dependent ecosystems beyond the area of direct clearing to determine their location, condition and vulnerability to projected groundwater drawdown

A detailed assessment of potential impacts on GDEs located both inside and outside the Project area is provided in the attached Appendix E. A summary of the assessment of groundwater drawdown is provided below.

Identification of potential GDEs was undertaken based on site specific observations (e.g. identification of potentially groundwater dependent flora species and communities during the ecology surveys) and data collected during the preparation of the specialist studies identified in Section 1 (e.g. identification of depth to groundwater, extent of saturated alluvium).

Terrestrial Riparian Vegetation

The terrestrial riparian vegetation associated with the Isaac River, North Creek, Cherwell Creek and the downstream reaches of Ripstone Creek may well have a high potential to be intermittently dependent on subsurface expression of groundwater (i.e. facultative GDEs) following period of heavy rainfall, when the thickness of saturate alluvium increases to the extent that these communities may be able to access it. These communities are unlikely to constantly rely on access to the groundwater under normal conditions for their survival.

Although potential drawdown of approximately 2 to 5 m is predicted to occur in areas where vegetation may be intermittently dependent on subsurface expression of groundwater, it is unlikely that this potential impact would result in a significant impact to terrestrial riparian vegetation. This is due to the fact that this vegetation is subject to continuous (natural) wetting and drying cycles and these communities are most likely facultative GDEs which rely more heavily on the replenishment of moisture in the soil following rainfall rather than access to the groundwater system. The Project would not result in a drawdown in the alluvial aquifers that would dewater the aquifer to the extent that it would not recover following rainfall (HydroSimulations, pers comm.).

Aquatic Habitats

Aquatic habitat within Isaac River and its tributaries may also have a high potential to intermittently use the surface expression of groundwater during occasional periods of baseflow from the adjacent/underlying alluvium after prolonged rainfall events or following flood events (i.e. facultative GDEs).

The Project would result in a potential 0.5% reduction in flow within the Isaac River during mining operations. It should be noted that this potential reduction only applies to the reach of the Isaac River adjacent to the Project area. Given the ephemeral nature of the Isaac River and the small local contribution of baseflow, which only occurs after periods of prolonged rainfall, this predicted reduction in baseflow is expected to have only a minimal impact on aquatic habitat within the Isaac River and associated tributaries.

The aquatic species that inhabit these waterways have adapted to wetting and drying cycles and are expected to persist in the environment despite the potential reduction in baseflow. Hydrosimulations (Appendix D of the draft EIS) also considered potential baseflow impacts to Ripstone Creek and concluded that there would be no discernible change in baseflow contributions.

Terrestrial Habitats

Terrestrial vegetation and aquatic habitat associated with the palustrine wetlands surrounding the Olive Downs South and Willunga domains are unlikely to constitute a GDE, given that groundwater levels in these areas have been identified as being in excess of 10 metres below ground level (mbgl).

It is likely that the terrestrial vegetation associated with wetlands relies on the slow percolation of surface water after rainfall events to sustain their health rather than direct access to the groundwater system. As such, the Project would not result in an adverse impact to these communities through any potential impacts to the groundwater system.

All other terrestrial vegetation within the Project locality have a low likelihood of being dependent on the presence of groundwater as the vegetation comprises eucalypt dry woodlands dominated by Poplar Box (*Eucalyptus populnea*) and the groundwater table is at least 10 mbgl, which would be too deep for these vegetation communities to rely upon.

e) consider avoidance and further mitigation measures for the proposed 2-km diversion of Ripstone Creek

A detailed description of the economic and operational impacts to the Project of not diverting Ripstone Creek is provided in Section 21, as well as a description of the proposed mitigation measures for the diversion. In summary, the principal economic cost of avoiding Ripstone Creek centres around the loss of product coal. Avoiding Ripstone Creek would necessitate the reduction in extent of mining the ODS9 open cut pit. An assessment of the potential loss of ROM coal has confirmed that approximately 3 million tonnes of ROM coal would remain in-situ.

Reducing the extent of ODS9 would impact the efficient extraction of the coal resource in ODS9, which would have flow on effects to other parts of the mining operation, including requirements for larger out-of-pit waste rock emplacements and additional mining fleet.

As outlined in Table 6-2 of the draft EIS, a monitoring strategy for the Ripstone Creek Diversion has also been developed and includes monitoring prior to construction, during operation and for relinquishment. Schedule I of the Proposed EA conditions (Appendix B) outlines Pembroke's requirements regarding the proposed diversion.

f) update surface water modelling to address deficiencies identified in the IESC advice (local streamflow gauging information). Modelling should be updated to inform detailed landform planning, particularly on the floodplain and the proposed diversion channel

It is noted that the IESC acknowledges the effort taken to ensure that the adopted methodology is consistent with the new national guidelines (Ball et al. 2016) and that the configuration of the regional flood event model is well suited to characterising flood risk at the larger scales of interest, and an excellent level of agreement has been achieved between model and observed characteristics at the Deverill gauging station. IESC Item 21(a) suggests that EITHER surface water modelling be revised OR the approach be explained. A detailed explanation of the approach, in response to the specific IESC comments is provided below.

It is important to consider that the key output of the regional flood hydrology scope for the Project was to enable description of the changes to upstream and downstream characteristics to address the Terms of Reference for the EIS. The level of detail for the modelling is considered fit-for-purpose in this regard (with concurrence by a peer reviewer), however it is expected that review and refinement of the flood hydrology modelling would be undertaken during the detailed design.

IESC Point 6 Response:

The IESC advice states:

> *The IESC also acknowledges the effort that the proponent has taken to ensure that the adopted methodology is consistent with the new national guidelines (Ball et al. 2016). However, while the large-scale estimates for the regional flood event model make good use of the available gauging and design information, little or no use appears to have been made of the eight other streamflow gauges in the local area. The upstream areas reporting to these gauges are of a similar size as the creeks near the Olive Downs Coking Coal Project Area and would provide valuable information on how flood peaks scale with area.*

The flood hydrology model for the Project EIS (Appendix F of the draft EIS) was calibrated to five historical flood events (August 1998, February 2008, December 2010, February 2016, and March 2017) using up to four (4) nearby gauging stations. While it is recognised there are other rainfall gauges and stream gauge records (of which most have ceased and no longer record) located within the catchment of Isaac River, the selection of the historic calibration events using the gauging stations to address the TOR requirements for the Project EIS was considered sufficient. Relevantly, recorded data of other nearby gauges (namely, Phillips Creek at Tayglen, Isaac River at Burton Gorge, Scott Creek at Norwich Park and Devlin Creek at Bombandy) did not cover any of the calibration events.

IESC Item 19:

The IESC advice states:

> *The natural inputs to the mine water management system are based on an Australian Water Balance Model (AWBM) (which has been calibrated to only one catchment of the Isaac River) and the use of stochastic rainfall replicates. It is concerning that the median observed annual rainfalls coincide with the lower (90%) bound of the synthetic series (Figure 5.8, Appendix E), which suggests that the typical annual synthetic inflows are biased high. However, this "high bias" would be partially offset by the underestimation of streamflows obtained using the AWBM model (Figure 7.5, Appendix E). Overall, it is possible that the water usage requirements associated with the predicted 10% (dry) climatic conditions are representative of the likely future typical (50%) requirements, without allowing for climate change. For example, the external makeup requirements associated with a 10% probability of exceedance might be better regarded as being associated with median climatic conditions. If this is of critical concern, then the efficacy of the stochastic rainfall replicates should be revised to be more consistent with local observations.*

As described in Section 5.2.2.1 of the draft EIS Surface Water Assessment (Hatch, 2018) report, a stochastically generated rainfall dataset was produced to provide a sufficient number of climatic sequences, given the long mine life. This stochastic rainfall dataset was generated using the Stochastic Climate Library (SCL) software, using the SILO rainfall data as the source data. The SCL software is effectively a "black box" type program, and does not provide any ability to modify parameters or settings which can change the results.

To test the efficacy of the program, WRM compared the source (SILO) rainfall data against the generated rainfall data (Figure 5-8 of the Surface Water Assessment reproduced below). This showed that, when ranked, the historical annual rainfall totals were generally within the 10^{th} and 90^{th} percentile bounds of the stochastic annual totals.

Some of the historical data was closer to the 10^{th} percentile, some closer to the 90^{th} percentile and some near the median. In WRM's opinion, the stochastically generated data was successfully replicating the historical data with a reasonable amount of variation and the use of the adopted stochastic rainfall dataset is acceptable for the following reasons:

- The SCL program has been designed specifically for this purpose (i.e. the generation of stochastic climate data based on historical climate data for Australian conditions). There are few other programs available which can generate daily climate sequences, especially for Australian conditions.
- While the position of the historical data varies between the 10^{th} and 90^{th} percentiles, the range of annual totals for the stochastic data at each AEP is fairly tight, with the spread increasing somewhat for the highest rainfall years (AEP <5%). Therefore the difference between the 10% and 90% totals is fairly small. Discounting the top 3 values, the average variation is only 85 mm/year. For most years, this equates to a variation of around 10-15% annual rainfall total.

- Any potential "bias" in the stochastic rainfall data is minor, and any uncertainty associated with the rainfall data would be captured within the sensitivity analysis presented in Section A.3 and A.4 of the Surface Water Assessment. As part of this sensitivity assessment, the AWBM soil capacity was adjusted by +/- 20% and the predicted impacts on the performance of the water management system was presented.
- Therefore, in WRM's opinion, the uncertainty associated with the generation of the stochastic rainfall data is adequately addressed through the model sensitivity analysis process.

In order to quantify the difference between the historical and stochastic rainfall data in terms of runoff volumes, WRM have undertaken an assessment of the long-term coefficient of runoff (C_v) for each of the modelled land disturbance types. This allows for a comparison between the difference in modelled long-term average runoff (rather than rainfall), and is presented in Table 5-2. Table 5-2 shows the following:

- There is very little difference in the effective Cv for the "Isaac River", "Natural" and "Rehab" land disturbance types (<3%).
- There is a slightly larger difference for the "Roads/Hardstand" and "Mining Pit" land types, however it is still less than 7.5%.
- The variation for "Spoil" is around 17%.
- While there is some variation in the long term Cv between the two datasets, it is considered reasonable given that the relationship between rainfall and runoff is not linear, and the SCL software targets multiple statistics in its calculation (not just average rainfall total). This is why WRM have undertaken a sensitivity analysis of +/- 20% for the rainfall runoff parameters to ensure that the impact of the uncertainty in the AWBM parameters is understood.

Table 5-2
Comparison of Long-term Runoff Coefficient (C_v)

Land Disturbance Type	Historical Rainfall data (%)	Stochastic Rainfall Data (%)
Isaac River	8.2%	8.0%
Natural/undisturbed	13.0%	13.3%
Roads/Hardstand	32.3%	34.7%
Mining pit	21.9%	23.4%
Spoil	8.5%	10.0%
Rehab	14.1%	14.5%

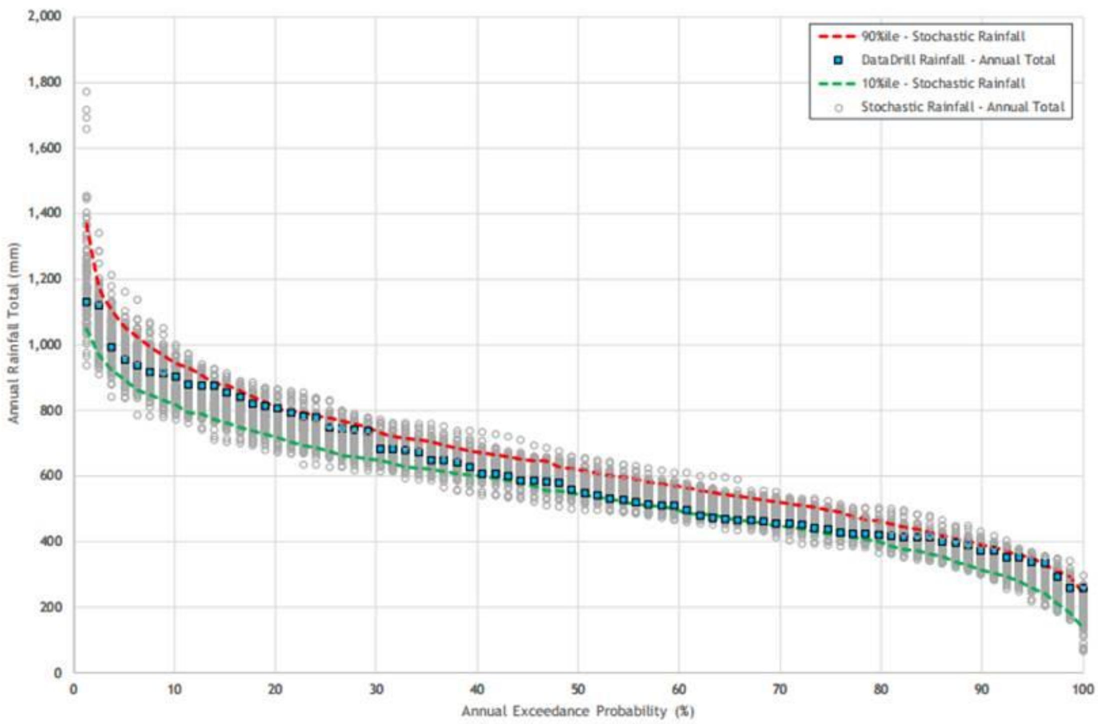

Figure 5-8: Comparison of DataDrill vs Stochastic Rainfall Data

IESC Point 21-a Response

The IESC advice states:

The configuration of the regional flood event model is well suited to characterising flood risk at the larger scales of interest, and an excellent level of agreement has been achieved between model and observed characteristics at the Deverill gauging station. However:

a. it is unclear why the proponent did not make use of stream flow records from the nearest gauge on Isaac River (at Deverill) in their flood event modelling to calculate design runoff. This should either be explained, or the modelling should be revised to make use of these data;

As outlined in Section 8 of the Flood Assessment provided in the draft EIS, the Deverill gauging station was primarily used to calibrate catchment model parameters. The design runoff was calculated using these parameters in conjunction with design intensity-frequency-duration rainfall data from Bureau of Meteorology.

It is noted that similar to the IESC comment, the Peer Review also recommended that further analysis be conducted during subsequent studies or detailed design to refine the design of the water management infrastructure, including improved catchment yield (flow) modelling of the Isaac River using streamflow data from the Deverill gauging station. Notwithstanding, the peer review found that this further analysis was considered unlikely to significantly affect the modelling outcomes/conclusions and therefore assessment of potential impacts already described in the Surface Water Assessment.

IESC Point 21-b Response

The IESC advice states:

> *In the regional flood event model, it is noted that there are only two or three model sub-areas upstream of the locations relevant to the other creeks near the Olive Downs Coking Coal Project area. While the adoption of approximately equal sub-areas in the flood event is generally to be preferred, in this application it presents two problems: first, the number of sub-areas upstream of these locations is probably insufficient to adequately characterise the storage routing characteristics in the local catchments, and second, these catchments are over an order of magnitude smaller than the scale at which the model has been verified;*

The adoption of approximately equal sub-catchments areas are essential in order to avoid overestimating or underestimating either volume or peak discharge from a catchment. Having said that, there are 41 sub-catchments (out of 90) located upstream of the Project area. This is considered to be sufficient to account for the storage routing characteristics in the local catchments and model validation.

IESC Point 21-c Response

The IESC advice states:

> *The development of individual flood event models are based on regional routing parameters and thus do not make good use of the information contained in the calibrated large-scale model. There is in general a factor of two difference between the local and regional model estimates, which does not provide good confidence in either set of estimates of flood risk; and*

The flood routing parameters used for this project have been adopted from a calibrated model (Flood Assessment Report, Section 7.5) and verified against regional routing parameters as a validation. It is also noted that through the peer review process a number of requests for clarification and suggestions for modifications to the flood modelling methodology were provided and the majority resolved to the peer reviewer's satisfaction, concluding "*It was resolved that the modelling as it stands is sufficient and fit for purpose for the EIS, in terms of the assessment of relative flood impacts*…"

IESC Point 21-d Response

The IESC advice states:

> *In addition to the difference in the estimates derived using the regional- and local-scale models, the IESC notes that the relationship between sub-catchment area and flood peaks does not vary in a manner consistent with physical reasoning. In order to reconcile the difference between the different model estimates and improve confidence in the estimates, it is suggested that additional information be compiled on how flood magnitude varies with catchment area. This is best undertaken using flood frequency quantiles derived from nearby gauging stations. Information from RFFE model estimates would also be helpful.*

While catchment area has a major influence on the total volume of runoff, combination of routing storage, average distance and shape factor determine the catchment response to rainfalls and peak discharges.

According to Dr William Weeks (main contributor of RFFE Model), the RFFE estimates are an indication of the design flows based on the regional catchment routing parameters, however flood frequency analysis is the preferred method of design flow validation where possible and, as such, was adopted for the Project (as outlined in the Flood Assessment provided in the draft EIS).

Notwithstanding, it should be recognised that flood estimates generated by the RFFE Model for a catchment with flood characteristics that are distinctly different from typical gauged catchments in the region may not only be associated with larger error margins but also significant bias. In such situations hydrological judgment must be exercised to assess if any adjustment of the regional flood frequency estimate is required (based on comparison of relevant catchment characteristics). To support such an assessment, the RFFE Model output describes the set of gauged catchments used in developing the RFFE Model, which are located closest to the ungauged catchment of interest. The following additional catchment attributes may need to be considered as a basis for adjustments to the flood estimates obtained directly from RFFE Model:

- Natural flood storage: large flood storage areas in catchments with extensive floodplains or swamps have the effect of attenuating flood peaks; flood estimates from RFFE Model would thus tend to overestimate peak flows and they could be regarded as upper bound flood estimates for these catchments.
- Drainage efficiency: steep catchments, streams with little vegetation along banks, catchments affected by large scale drainage or flood protection works can be expected to produce faster flood flows, less attenuation and thus higher peak flows; flood estimates from RFFE Model would thus tend to underestimate peak flows and they could be regarded as lower bound flood estimates for these catchments.

IESC Point 22 Response

The IESC advice states:

> *It is not entirely clear how the temporal pattern ensembles have been used. While it is appropriate to adopt a single representative temporal pattern to derive inputs to the TUFLOW model, the peaks of such hydrographs should be scaled to match the average peak obtained from the flood event model ensembles based on approximately ten temporal patterns.*

The methodology adopted for the selection of critical temporal pattern was in accordance with Australian Rainfall and Runoff, Book 2, Section 5.9.2. Given the simulation times of two-dimensional hydraulic models, ARR suggests that is not practical to hydraulically run all 10 patterns for multiple durations. As an illustration, a full set of hydraulic model simulations of the Project EIS for the critical temporal pattern took approximately one week, excluding post-processing of the results.

The size of each result file for every parameter (depth, height, velocity, stream power and shear stress) is approximately 4 Gigabytes. The required time and digital size of this magnitude is considered unnecessary and disproportionate for the purpose of such an EIS study.

According to ARR, a more practical approach would be to run a separate hydrological modelling process of the whole catchment of interest in order to determine the average pattern in terms of peak flow or volume depending on the problem. Therefore, this method was adopted for the Project EIS study.

g) provide a trigger action response plan as part of the water management plan that outlines effective mitigation actions to be taken when there is a suspected exceedance of a trigger value

Pembroke has proposed EA Condition F27 which will require the preparation of a Water Management Plan, including TARPs that outlines effective mitigation actions to be taken when there is a suspected exceedance of a trigger value.

h) *provide information on relevant recent regional impacts to Queensland and Commonwealth- listed species and to wetlands, and an assessment of the cumulative potential impacts to the Isaac River from nearby mining activities*

As stated in Section 3.3.9.9 of the draft EIS, the cumulative surface water impacts of all projects in the region on the environmental values of the receiving waters and cumulative groundwater depressurisation and drawdown with surrounding mines and the Bowen Gas Project, were considered and assessed.

Cumulative impacts on water resources are described in Section 3.3.10.3 of the draft EIS, including Catchment Excision, Water Releases, Flooding and Groundwater Depressurisation and Drawdown.

Notwithstanding, additional assessment of potential impacts to wetlands has been undertaken and is provided in Appendix E.

i) *consider further avoidance and mitigation options for the two final voids proposed to be placed on the Isaac River's floodplain.*

The Project final landform would include three final voids, two within the Olive Downs South domain (Figure 5-2 of the draft EIS) and one within the Willunga domain (Figure 5-3 of the draft EIS). As described in Sections 4.3 of the draft EIS, final void waterbodies are predicted to equilibrate below the regional groundwater table, meaning the voids would act as groundwater sinks into perpetuity, preventing potentially contaminated water migrating into surrounding aquifers. The final void waterbodies are not predicted to spill to the surrounding environment, as they would remain at least 90 m below ground level.

The final voids within the Olive Downs South domain would be isolated from all flood waters up to and including a PMF event by permanent waste rock emplacements (referred to as permanent highwall emplacements). These permanent highwall emplacements would integrate with the in-pit and out-of-pit waste rock emplacements, effectively surrounding the final voids and redefining the Isaac River floodplain extent.

The Willunga domain final void is located beyond the extent of potential flood impacts from the Isaac River.

Additional information outlining how voids would be isolated from potential floodwaters, particularly in response to comment #9 received from DES, is provided in Section 24.