BOWDENS SILVER

Response to Earth Systems Review – Water Balance Modelling and Surface Water Management

State Significant Development No. 5765

October 2022

Prepared by: R.W. CORKERY & CO. PTY. LIMITED

Bowdens Silver Project

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1. Introduction

1.1 Scope

This document has been compiled by R.W. Corkery & Co. Pty Limited and WRM Water and Environment Pty Ltd to provide a response to the 11 recommendations made in the *Independent Review – Water Balance Modelling and Surface Water Management*, prepared by Earth Systems and hereafter referred to as Earth Systems (2022). This review was commissioned by the Department of Planning and Environment (DPE) to independently review information provided in relation to the site water balance modelling and proposed management of surface water at the Bowdens Silver Project (the Project). The review was provided to Bowdens Silver Pty Limited (Bowdens Silver) on 8 June 2022.

1.2 Background

With regards to the Project's site water balance modelling and proposed management of surface water the DPE commissioned Earth Systems to review the following documents that were prepared to support the Project's Development Application (SSD 5765) and placed on public exhibition from Tuesday 2 June 2020 until Monday 27 July 2020.

- *Environmental Impact Statement – 2020* (EIS). Prepared by R.W. Corkery & Co. Pty Limited (RWC, 2020) on behalf of Bowdens Silver Pty Limited.
- *Materials Characterisation Assessment – 2020*. Prepared by Graeme Campbell & Associates Pty Ltd (GCA, 2020) on behalf of Bowdens Silver Pty Limited and presented as Part 3 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.
- *Tailings Storage Facility Preliminary Design – 2020*. Prepared by ATC Williams Pty Ltd (ATC Williams, 2020) on behalf of Bowdens Silver Pty Limited and presented as Part 16c of the *Specialist Consultant Studies Compendium* which accompanied the EIS.
- *Preliminary Design of PAF Waste Rock Emplacement, Oxide Ore Stockpile and the Southern Barrier – 2020*. Prepared by Advisian – Worley Group (Advisian, 2020) on behalf of Bowdens Silver Pty Limited and presented as Part 16b of the *Specialist Consultant Studies Compendium* which accompanied the EIS.
- *Surface Water Assessment – 2020*. Prepared by WRM Water and Environment Pty Ltd (WRM, 2020) on behalf of Bowdens Silver Pty Limited and presented as Part 6 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.
- *Groundwater Impact Assessment – 2020*. Prepared by Jacobs Group (Australia) Pty Limited (Jacobs, 2020) on behalf of Bowdens Silver Pty Limited and presented as Part 5 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

Following public exhibition, a comprehensive response to the matters raised in submissions responding to the EIS were presented in the *Submissions Report* for the Project (RWC, 2021) that was provided to DPE in June 2021. DPE also provided the *Submissions Report* to Earth Systems for review.

As Bowdens Silver then decided to defer the option to use a pipeline to supply water to the Mine Site, this aspect of the Project was formally removed from the development application. To support the amendment to SSD 5765, the *Water Supply Amendment Report* (RWC, 2022a) was prepared. This report considered the implications of Bowdens Silver's intention to rely on water sources within the Mine Site for the Project's water supply requirements and included the following updated assessments:

- *Updated Surface Water Assessment – 2022*. Prepared by WRM Water and Environment Pty Ltd (WRM, 2022) on behalf of Bowdens Silver Pty Limited and presented as Appendix 3 of the *Water Supply Amendment Report*.
- *Updated Groundwater Impact Assessment – 2022*. Prepared by Jacobs Group (Australia) Pty Limited (Jacobs, 2022) on behalf of Bowdens Silver Pty Limited and presented as Appendix 4 of the *Water Supply Amendment Report*.

The *Water Supply Amendment Report*, including WRM (2022) and Jacobs (2022) were placed on public exhibition from 25 March 2022 to 7 April 2022. These reports were also provided to Earth Systems for review. It is however noted that both WRM (2022) and Jacobs (2022) superseded the 2020 versions of their respective assessments.

1.3 Summary of Matters Raised

Key matters raised by Earth Systems principally concerned the input data used for the site water balance modelling (i.e. climatic, streamflow and model parameterisation) and the effect this approach has on the Project's overall water supply reliability and water management. Earth Systems also provided overarching commentary on the Project's surface water assessment such as:

- model uncertainty and sensitivity analysis;
- terminology adopted in water balance reporting;
- the management of runoff and water quality risks; and
- the management of seepage from tailings.

1.4 Approach to the Response

The level of detail presented in the EIS and supporting documents has been sufficient to satisfy NSW Government agencies such as the Department of Planning and Environment Water (DPE-Water) and the Environment Protection Authority (EPA) regarding surface water management and the protection of receiving systems. Detailed information was presented within and appended to the EIS and subsequent reporting that adopted a conservative approach to assessing potential impacts on water resources. The review undertaken by Earth Systems has queried the underlying assumptions of the site water balance modelling and therefore the outcomes of the information presented in documentation supporting SSD-5765. It is acknowledged that Earth Systems' review may have been assisted by further information on the supporting rationale for some modelling assumptions, or (where required) changes clarified, in the documents reviewed. However, Bowdens Silver confirms that the approach taken reflects current industry best practice and the assessments provide DPE with sufficient information for determination of the application. The outcomes of works undertaken to inform this response provides important context for consideration of the Project's water balance modelling outcomes and proposed water management strategy.

This document provides a detailed response to the recommendations of Earth Systems whilst **Appendix 1** presents a response to all matters raised. This document also presents a summary of actions that would occur prior to commencement of mining and over the life of the Project.

1.5 Summary of Outcomes

The preparation of this response has relied upon the detailed site water balance model developed by WRM. This model utilised an Australian Water Balance Model (AWBM) to derive catchment yields as model input. This AWBM was calibrated to long-term data obtained from WaterNSW's Cudgegong River Upstream of Rylstone streamflow gauge (421184). AWBM runoff parameters and catchment land-use types were defined based on WRM's experience at operational mine sites in the region.

In the absence of long-term data collection in the vicinity of the Project, a 130-year climatic dataset for the site water balance model (rainfall inputs and evaporation output) was obtained from the Queensland Department of Environment and Science, Scientific Information for

Landowners (SILO) data service[1]. This service, widely used by industry and research agencies, was developed in collaboration with the Bureau of Meteorology (BoM) to provide accurate, reliable and gap-free long-term climate data derived from observational records and interpolation, for the purpose of biophysical modelling. The SILO data used for the site water balance has been the subject of comparative analysis with historical BoM data, local landholder records and data collected from Bowdens Silver's weather station. These analyses confirm that the SILO data used for the site water balance is representative of the local climate across the range of expected conditions (i.e. high and low rainfall periods), thus providing a reliable basis on which to assess the Project's:

- water management strategy;
- water supply reliability; and
- potential impacts on downstream water users.

It is acknowledged that detailed model outputs were not provided in publicly available documents. However, these documents were in a form considered accessible to all readers that presented an appropriate level of detail on the methodology and outcomes of the assessment. It is noted that these documents were acceptable to DPE-Water and the EPA. In addition, the approach and execution of the site water balance modelling by WRM was the subject of an independent peer review, commissioned by Bowdens Silver and undertaken by Mr Tony Marszalek of ATC Williams Pty Ltd, a highly experienced and respected modeller in this field. Notwithstanding this, WRM can provide Earth Systems with full access to all model realisations, including parameterisation and daily results.

The Project's water management strategy was developed based on the type of disturbance in the contributing catchment whereby:

- potentially contaminated water is fully contained within the containment zone;
- runoff from cleared catchments disturbed by mining activities would be managed in the erosion and sediment control zone providing containment for the 5% annual exceedance probability 72-hour design rainfall event plus an additional sediment storage zone; and
- Runoff from undisturbed catchments (clean water zone) would be either captured in basic landholder (harvestable rights) dams or diverted for discharge to downstream receivers.

The site water balance model confirmed that:

- the proposed water management strategy would effectively manage all runoff without the need to discharge from either the containment or erosion and sediment control zone, even under the high runoff conditions modelled for uncertainty;
- the Project is reliably supplied with water across the full range of historical climate conditions, including the low runoff conditions modelled for uncertainty; and
- The Project's water management and supply strategy would result in negligible impact to downstream water users.

[1] https://www.longpaddock.qld.gov.au/silo/

2. Scientific Information for Landowners (SILO) Data

Accurate and efficient site water balance modelling requires temporally complete and accurate rainfall and climate data. The comments provided in Earth Systems (2022) make several references to the accuracy of the SILO rainfall data used in the surface water assessment for the Project. Prior to the development of SILO, assessments such as that prepared by WRM would utilise data from the nearest rainfall station, with data from other nearby rainfall stations substituted for missing data points to create a composited rainfall dataset. However, as substituted data is drawn from a location with different attributes that influence rainfall (e.g. site elevation, local topography and land use), it would not necessarily provide an accurate reflection of site conditions.

The SILO data service was developed by the Queensland Government, in collaboration with BoM to provide spatially and temporally complete climate datasets for biophysical modelling. The service collates raw observational data from BoM station records (or other providers) and processes it to produce interpolated datasets. These datasets are available for either BoM station locations or at the centroids of 5km x 5km (0.05° x 0.05°) grid cells which extend across Australia. As SILO is fitted to BoM station data, it accurately reproduces observed data (at the point of observation) with only minor differences arising from data interpolation. For this reason, SILO is commonly used by hydrological consultants, research agencies such as CSIRO and the Murray-Darling Basin Authority and State agencies.

Whilst there are two historical BoM stations in Lue (Lue Station and Bayly Street), neither provide publicly available, long-term, contemporary or complete rainfall records. Therefore, SILO was selected as it provided a complete 130-year rainfall dataset generated using robust mathematical methods.

The *Updated Surface Water Assessment* prepared by WRM (WRM, 2022) utilised a complete and long-term SILO climate dataset as:

- a key element of the Project's water balance; and
- the means to quantify and assess the Project's impacts on local surface water resources.

It is noted that SILO regularly reviews and updates data processing methods and inputs. Since the generation of the Project's original dataset, there have been three material updates to SILO. These included two updates (8 July 2020 and 15 June 2022) that incorporated revised BoM data and one (25 September 2019) that addressed an interpolation error in rainfall data. For the Project, WRM obtained two datasets from SILO, one on 2 January 2019 and another on 30 September 2019. Both datasets were for the grid point located at latitude 32.60 degrees South and longitude 149.85 degrees East, (1.6 km north of the Mine Site). The data covered the 130-year period between 1 January 1889 to 31 December 2018.

During the early stage of the assessment, WRM used the January 2019 SILO dataset to generate Figures 3.1, 3.2 and 3.3 of WRM (2022) whilst the September 2019 dataset was later used for modelling catchment yields via an Australian Water Balance Model (AWBM) developed to provide runoff inputs to the site water balance modelling used for the assessment. This September 2019 dataset also reflects a change in SILO's interpolation method (from using monthly observational data to daily). It was therefore important that this data was sourced and used. However, a clerical oversight has meant that Figures 3.1, 3.2 and 3.3 of WRM (2022) were not updated with the September 2019 dataset.

For completeness, updated Figures 3.1, 3.2 and 3.3 of WRM (2022), are provided as **Figures 1**, **2** and **3** and prepared using the September 2019 SILO dataset are presented below. Review of **Figures 1** and **2** identify a decrease in both annual total rainfall depths and average monthly rainfall whilst evaporation remains largely unchanged. The linear regression analysis presented on **Figure 3** displays the correlation (R^2 value) between measured (Mine Site) and SILO monthly rainfall data. Such an analysis is used to assess the strength of data correlation whereby 0 = weak and 1 = strong. **Figure 3** shows the September 2019 dataset as having an even stronger correlation ($R^2 = 0.95$) than that derived from the January 2019 dataset ($R^2 = 0.93$).

This SILO data has also been the subject of comparative analysis with historical BoM data and local landholder records. These analyses, presented in the *Water Supply Submissions Report*, alongside the linear regression analysis described above and shown on **Figure 3**, confirm the SILO data used for the site water balance modelling is representative of the local climate across the range of expected conditions (i.e. high and low rainfall periods).

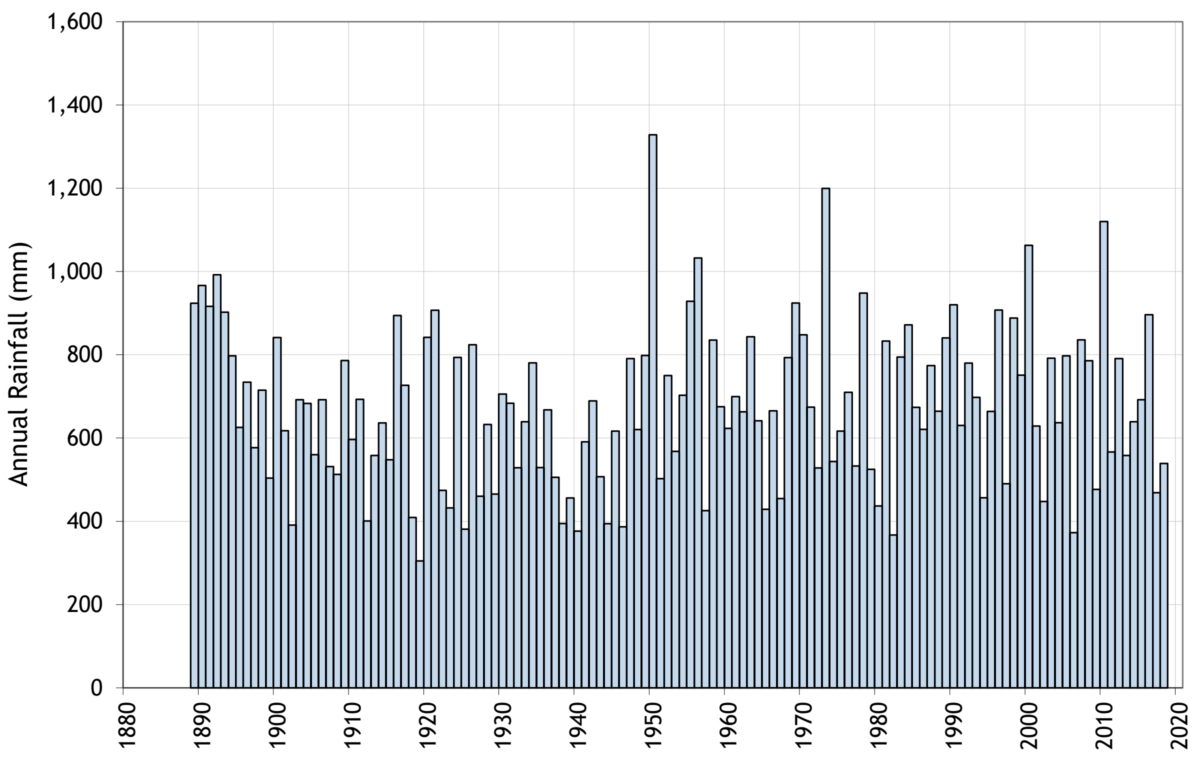

Figure 1
Annual rainfall at the Mine Site - 1889 to 2018 (source: SILO point dataset - Qld Department of Environment and Science, 30 September 2019)

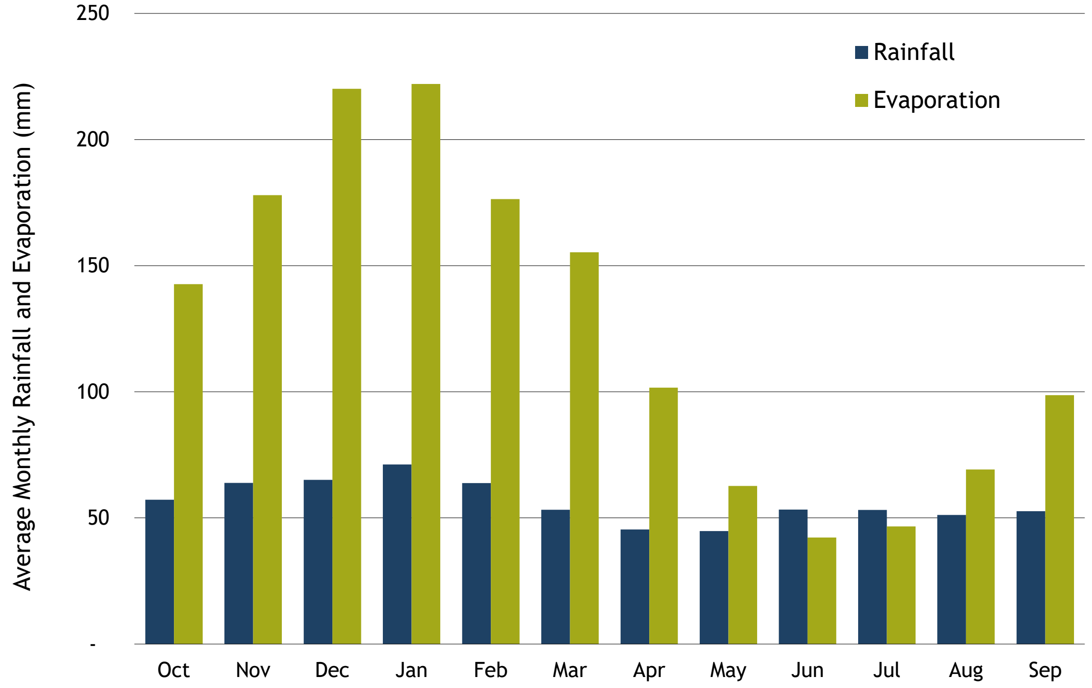

Figure 2
Average monthly rainfall and pan evaporation at the Mine Site - 1889 to 2018 source: SILO point dataset - Qld Department of Environment and Science, 30 September 2019)

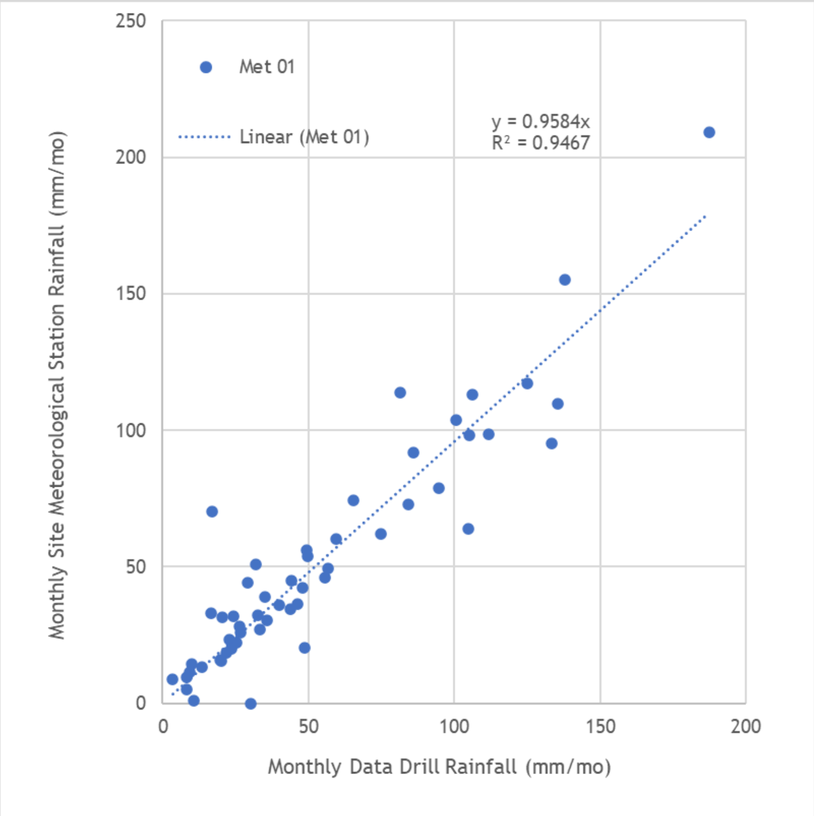

Figure 3
Comparison of monthly rainfall data from Bowdens Silver meteorological station and SILO data

3. Response to Earth Systems' Recommendations

The following section provides a response to the 11 recommendations of Earth Systems (2022). These recommendations are a summary of a range of matters described in Earth Systems (2022) with a brief response to each matter raised by Earth Systems provided as Appendix 1.

Recommendation

The site water balance model results are considered preliminary only due to a lack of long-term site rainfall and flow data, simplification of land use types, and uncertain runoff characteristics. Furthermore, the modelling method presented is lacking in some key details, and clear justification for model assumptions is not always provided. The sensitivity analysis is also very limited. Clarification of the method, more detailed review (QA/QC) and further sensitivity analysis would improve understanding of water supply reliability and the risk of uncontrolled discharge.

Response

Neither Bowdens Silver or WRM agree with or accept the statement that the water balance results are preliminary. Apart from population centres, there are very few locations worldwide and especially in rural locations, with quality controlled, verifiable climate and flow datasets that have been collected over a long-term period. As the Project is yet to be developed and situated in a historically agricultural setting, the site water balance may contain some inherent uncertainty associated with predicting future climate and catchment responses. However, catchment yields were developed using an AWBM that was parameterised based on WRM's experience calibrating models at operational mine sites in the region. The purpose of the Project's site water balance modelling was to predict, assess and demonstrate that, under historical climate conditions:

- the proposed site water management strategies could effectively contain runoff from catchments disturbed by Project-related activities;
- the Project could be reliably supplied with water for operations and dust suppression; and
- potential impacts to downstream users are acceptable and able to be licensed under NSW's bulk access regime for water resources.

Low runoff scenarios were also tested to predict and assess what might occur, what are the implications for the local environment and to identify how such outcomes may be mitigated. This form of sensitivity analysis was undertaken to provide a high level of confidence that the Project's conceptual design was sufficiently robust to performing effectively under more severe conditions than what the base case modelling and climate parameters would suggest.

The assessment of potential impacts to downstream users assumed all runoff from catchments disturbed by Project-related activities would be contained on within the Mine Site. Therefore, any parameter uncertainty associated with this aspect of the assessment does not affect its outcomes. Regarding daily streamflow in Lawsons Creek, this aspect of the assessment was developed using the AWBM rainfall / runoff model that was calibrated to the closest available long-term streamflow gauge. In addition, model uncertainties from transposing runoff to the

Lawsons Creek catchment are mitigated by using consistent datasets for the pre- and post-development scenarios. This means that the overall outcomes of the assessment are unlikely to be materially affected by model uncertainty.

It must also be emphasised that all water management structures will be the subject of detailed design, prior to construction, commissioning and operations. This aspect of Project development would fully define design storage capacities using upon the most contemporary data and design guidance available. This is especially critical for key containment storages, such as the Tailing Storage Facility (TSF) and Leachate Management Dam that will be sized on a design rainfall event basis in accordance with regulatory and industry standards. Therefore, the design of these critical elements for Mine Site water management are largely independent of the modelled climate or parameter sets.

The approach and execution of the site water balance modelling by WRM was the subject of an independent peer review, commissioned by Bowdens Silver and undertaken by Mr Tony Marszalek, a highly experienced and a highly respected modeller in this field. Furthermore, DPE-Water, the NSW department tasked with managing the State's water resources under the NSW *Water Management Act 2000*, was satisfied with the approach and assessment outcomes.

Responses to specific issues raised by the review are outlined below:

- *lack of long-term site rainfall and flow data* – There is no publicly available, long-term rainfall or streamflow dataset for a location proximal to the Mine Site. This is not an unusual or unique situation for this Project or many others that have previously been approved. The use of SILO climate data:
  - is entirely appropriate for the level of detail required for an EIS;
  - is a commonly adopted and accepted approach for similar studies at greenfield sites; and
  - would not materially affect the outcomes of the investigation.
- *simplification of land use types* – The land-use categorisations used for the AWBM and site water balance are consistent with those adopted for similar studies at operational mine sites in the region. Such categorisation allows for the application of calibrated AWBM parameters that have been obtained from these mine sites. In the absence of site specific data to justify the selection of runoff parameters, further sub-catchment categorisation by land use types would provide very minor improvement to model accuracy whilst increasing uncertainty through the addition of further complexity.
- *uncertain runoff characteristics* – As noted above, the selected AWBM parameters are based on calibrated values derived from similar land use types at mine sites within the region. Any uncertainty associated with runoff at the Mine Site is appropriately dealt with via the sensitivity analysis described in the assessment.
- *is lacking in some key details* – WRM (2022) presents the outcomes of a substantial modelling assessment derived from a range of results. Whilst it is agreed that detailed output datasets were not provided in publicly facing documents, an appropriate level detail was provided in a form accessible to all readers. However, what was provided has been sufficient historically for the EIS assessment stage of mining projects in NSW and was acceptable to DPE-Water and the NSW EPA.

- *and clear justification for model assumptions is not always provided* – WRM relied upon extensive experience developing and calibrating similar site water balance models, at existing mining operations in the region. Whilst much of this information is, unfortunately, not publicly available, it aligns with accepted approaches whilst the uncertainty in model assumptions was tested via sensitivity analyses.
- *sensitivity analysis is also very limited* – Neither Bowdens Silver or WRM agree with or accept this statement. WRM assessed sensitivity of the site water balance model to the key parameters with the potential to materially affect the outcomes. These include the runoff model parameterisation and groundwater inflows – and is an entirely appropriate and robust approach that is consistent with other similar projects that have subsequently been approved.
- *more detailed review (QA/QC) and further sensitivity analysis would improve understanding of water supply reliability and the risk of uncontrolled discharge* – Neither Bowdens Silver or WRM agree with or accept this statement. WRM conservatively assessed the Project's site water supply reliability and downstream impacts via an extensive and appropriate sensitivity analysis. Significant rainfall events within the site water balance model were invariably embedded in wetter periods with catchments already saturated prior to the rainfall event. This meant that modelled catchment behaviour during wet periods was not highly sensitive to catchment parameterisation and the assessment of potential Mine Site discharge well constrained.

  However, it is acknowledged that WRM (2022) incorrectly presented some information as being used in the AWBM and site water balance model. These represent minor reporting errors that have no material impact on the outcomes of WRM (2022) and which include:

  – the climatic information in Section 3 of WRM (2022), as identified and discussed in Section 2.1;

  – the AWBM parameters used in the sensitivity analysis and presented as Tables 5.9 and 5.10 of WRM (2022) with the correct parameters provided as **bold** values in the **Tables 1** and **2** below; and

  – the sensitivity analysis results presented as Tables 5.11, 5.12 and 5.13 of WRM (2022) with corrected results provided as **bold** values in **Tables 4**, **5** and **6**. These corrected results are for retained ore and tailings moisture and modelled plant losses that cumulatively alter the annual increase to stored water that is also corrected.

Table 1
Adopted AWBM Parameters – Low Runoff Scenario
(correction to Table 5.9 of WRM [2022])

Parameter	Dry Tailings Beach (TSF)	Natural / Undisturbed	Roads / Hardstand / Pits	Waste Rock Emplacement	Rehabilitation	Lined
A1	0.134	0.2	0.134	0.2	0.2	1
A2	0.433	0.2	0.433	0.2	0.2	0
A3	0.433	0.6	0.433	0.6	0.6	0
C1 (mm)	**8**	90	**8**	90	90	**10**
C2 (mm)	**15**	**185**	**25**	**185**	**185**	-
C3 (mm)	**25**	**215**	**45**	**230**	**230**	-
Cavg (mm)	**18.4**	**184**	**31.4**	**193**	**193**	**10**
BFI	0	0.6	0	0.6	0.6	0
Kbase	0	0.7	0	0.7	0.7	0
Ksurf	0	0.4	0	0.4	0.4	0
Average Annual Runoff/ Rainfall (%)	**31.4**	**2.4**	**23.3**	**2.2**	**2.2**	**41**
Average Annual Runoff (ML/ha/a)	**2.11**	**0.16**	**1.6**	**0.15**	**0.15**	**2.76**

Table 2
Adopted AWBM Parameters – High Runoff Scenario
(correction to Table 5.10 of WRM [2022])

Parameter	Dry Tailings Beach (TSF)	Natural / Undisturbed	Roads / Hardstand / Pits	Waste Rock Emplacement	Rehabilitation	Lined
A1	1	0.2	0.134	0.134	0.134	1
A2	0	0.2	0.433	0.433	0.433	0
A3	0	0.6	0.433	0.433	0.433	0
C1 (mm)	8	25	5	10	11	**2**
C2 (mm)	-	95	10	50	60	-
C3 (mm)	-	150	20	120	130	-
Cavg (mm)	8	114	13.7	75	83.7	2
BFI	0	0.55	0	0.35	0.35	0
Kbase	0	0.7	0	0.6	0.6	0
Ksurf	0	0	0	0.1	0.1	0
Average Annual Runoff/ Rainfall (%)	**44.6**	**8**	**37.1**	**13.3**	**11.7**	60.1
Average Annual Runoff (ML/ha/a)	**3**	**0.54**	**2.49**	**0.89**	**0.89**	**4.04**

Table 3
Average Annual Site Water Balance – Years 1 to 14 – Low Runoff Scenario (correction to Table 5.11 of WRM [2022])

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	740	
Net groundwater inflows to open cut pit	431	
Advanced dewatering	380	
Clean water harvesting	22	
Ore moisture	82	
Retained tailings moisture		**1,129**
Evaporation		356
Dust suppression demands supplied		131
Concentrate moisture		**6**
Other plant losses		19
Dam overflows		0
Annual increase in stored volume		**14**
Total	1,655	1,655

Table 4
Average Annual Site Water Balance – Years 1 to 14 – High Runoff Scenario (correction to Table 5.12 of WRM [2022])

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	1,109	
Net groundwater inflows to open cut pit	431	
Advanced dewatering	380	
Clean water harvesting	58	
Ore moisture	83	
Retained tailings moisture		**1,146**
Evaporation		614
Dust suppression demands supplied		132
Concentrate moisture		**6**
Other plant losses		20
Dam overflows		0
Annual increase in stored volume		**143**
Total	2,061	2,061

Table 5
Average Annual Site Water Balance – Years 1 to 14 – Low Groundwater Inflow Scenario (correction to Table 5.13 of WRM [2022])

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	811	
Net groundwater inflows to open cut pit	215	
Advanced dewatering	190	
Clean water harvesting	40	
Ore moisture	**71**	
Retained tailings moisture		**979**
Evaporation		211
Dust suppression demands supplied		119
Concentrate moisture		**5**
Other plant losses		**18**
Dam overflows		0
Annual increase in stored volume		**-4**
Total	**1,327**	**1,327**

Recommendation

The site water balance model does not incorporate a water quality component. This is required to assess whether site water is fit for purpose, to fully assess potential impacts on receiving waters (e.g. from TSF seepage) and to develop treatment or other management strategies.

Response

As the proposed Mine Site water management system is designed for full containment, it renders redundant the need for a water quality component to the site water balance model. However, the kinetic testing outcomes presented in *Materials Characterisation Assessment* prepared by Graeme Campbell & Associates Pty Ltd (GCA, 2020) provide a good understanding of potential runoff water quality from NAF materials whilst all PAF waste material would be placed in purpose built, lined infrastructure where runoff, seepage and leachate would be managed.

Whilst storage and evapoconcentration in the proposed Mine Site water management system may result in increased concentrations of potential contaminants over time, where this has the potential to impact processing, the Project would employ blending of water sources to ensure all water would be suitable for processing purposes. Water for dust suppression would primarily be sourced from clean water (harvestable rights) dams or abstracted groundwater. Potential impacts from TSF seepage was assessed in RWC (2021) and Jacobs (2022) with this highly conservative assessment identifying acceptable outcomes for downstream receivers in Lawsons Creek.

Recommendation

Outputs of the site water balance model are generally only presented as a single average value over a 14 year mine life. This level of detail is insufficient to independently assess water volumes and flows for individual water storage facilities, and how these will vary over time throughout *the mine life. Furthermore, confidence in the model outputs is limited by the unclear terminology / definitions for some model "inflows" and "outflows" and a lack of clear explanation of some significant changes in the model outputs from 2020 to 2022. More detailed presentation of model outputs and/or clarification of recent changes is warranted.*

Response

The presentation of average water balance outcomes is considered entirely appropriate for **predictive** assessment of a 16.5-year Project-life. As the assessment utilised historical climate data, it is not unreasonable to assume that a range of rainfall conditions would be experienced during this Project-life that, when considered overall, is best represented as average values for the purpose of assessment by regulatory agencies.

Full modelled water inventories for the TSF and main open cut pit over the Project-life and with probability of exceedance are clearly provided in Section 5.6 of WRM (2022) as percentiles derived from the results of probabilistic simulation. As these represent the ultimate endpoints for water management, when and if required, these inventories are critical elements in demonstrating no discharge from the Mine Site can be achieved.

Regarding unclear terminology, it is assumed that this refers to rainfall / runoff. Whilst this may be potentially confusing, it is a widely accepted hydrologic term whereby:

- runoff is that component of the water balance where overland flow is generated from a rainfall event of sufficient magnitude; and
- rainfall is that component of the water balance that is the direct contribution of meteoric rainfall onto a ponded surface within a water storage (i.e. the TSF decant pond).

Whilst it must be noted again that WRM (2022) supersedes the assessment that accompanied the EIS (WRM, 2020), the increase to model outputs arise from the:

- increased lined surface area of the TSF as part of Bowdens Silvers' voluntary seepage mitigation measures, as described in RWC (2021); and
- increased surface water harvesting from basic landholder (harvestable rights) dams.

The level of detail provided was to the satisfaction of DPE-Water and the EPA. However, it is acknowledged that daily results from individual realisations would assist detailed technical review. Access to all model realisations, including parameterisation and daily results can be provided for Earth Systems' review.

Recommendation

The water balance modelling results for the proposed amendment (WRM, 2022) indicate an increased risk of a water supply shortfall for the project, relative to the original project design in the EIS. For the proposed amendment, sensitivity analysis indicates that only 86% (average) or 65% (worst case) of the processing plant water requirement may be met. This risk was considered acceptable to Bowdens Silver in terms of the financial viability of the project. A review of this conclusion may be warranted in light of the model limitations outlined herein.

Response

The basis for this recommendation is drawn from the results of the sensitivity analysis of a water balance scenario whereby groundwater inflows are reduced from those assumed for the base case (average conditions) scenario[2]. Whilst this presents a pessimistic outcome for the Project, it is based on a low-probability scenario and Bowdens Silver accepts the associated operational risk. However, uncertainty analysis of the groundwater modelling generally indicates that groundwater inflows such as those considered for this scenario are unlikely.

Furthermore, as detailed in previous responses, modelled catchment parameters derived from calibrated mine sites in the region mean that Bowdens Silver and WRM are confident in the modelling used to evaluate the water supply strategy for the Project.

Recommendation

For the final pit void water balance model, there appear to be significant uncertainties in some key model input parameters such as pit catchment area, pit wall evaporation rates and pit lake evaporation rates. Confidence in the final pit void model outputs is limited by the lack of a clear explanation of some significant changes in the model outputs from 2020 to 2022. More detailed presentation of model outputs and/or clarification of recent changes is warranted.

Response

An analysis of final void pit lake behaviour has been undertaken that includes:

- detailed uncertainty analysis by HydroAlgorithmics Pty Limited of Jacobs' EIS groundwater model; and
- detailed uncertainty analysis by WRM of the final void water balance model using output from HydroAlgorithmics and evaporation parameterisation.

The results of this comprehensive analysis is presented in Bowdens Silvers' *Final Void Uncertainty Analysis Report – October 2022* and is not discussed further in this document.

Changed outputs between the WRM (2020) and WRM (2022) modelling were the result of WRM inadvertently enabling unscheduled timesteps in the final void model water balance model used for WRM's 2020 assessment. This introduced surprisingly high errors in the incorporated AWBM runoff model (which is strictly a daily timestep model) but this was corrected in subsequent model revisions.

Recommendation

The risk of pit lake water throughflow in groundwater towards Hawkins Creek, and the potential for AMD in pit water, needs to be considered and impacts on receiving water quality assessed. This also needs to consider potential contaminants in pit water from other sources (e.g. leachate dam, TSF, process water). A comprehensive pit lake water quality assessment and management strategy is required.

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[2] It is noted that rainfall / runoff contributions to the site water balance presented in Table 5.13 of WRM (2022) are lower (811ML/year) than the 856ML/year presented for the base case (refer Table 5.5 of WRM [2022]). This is due to a smaller TSF decant pond area (as decant pond water is removed to account for reduced groundwater input) that reduces direct rainfall contributions to the water balance.

Response

As noted above, the outcomes of the comprehensive final void uncertainty analysis are presented in Bowdens Silvers' *Final Void Uncertainty Analysis Report – October 2022*. However, it is noted that technically feasible outcomes ensuring the main open cut pit remains a terminal sink have been identified and assessed. Further details are provided in the *Final Void Uncertainty Analysis Report – October 2022* and are not considered further in this document.

Recommendation

TSF seepage modelling indicates potential surface water quality impacts (e.g. copper, zinc, cyanide and phosphorus) in Lawsons Creek, as well as groundwater quality impacts. Such impacts could be further exacerbated by AMD generation from PAF tailings, addition of other contaminants from the mine site / process plant water, or concentration of contaminants due to water re-circulation. A comprehensive TSF seepage quality management strategy is required.

Response

As noted in Section 8.4 of Jacobs (2022), a TSF Seepage Management Plan would be developed in tandem with detailed design of the TSF.

The assessment of impacts to Lawsons Creek as the result of TSF seepage was presented in Jacobs (2022) and RWC (2021). In summary, the assessment outcomes for potential water quality impacts from seepage were inherently conservative, as all natural processes and reactions that will occur within the TSF and along the flow path were excluded from consideration. Furthermore, in many instances where modelled water quality would be outside guideline values for aquatic ecosystem protection, these instances invariably arise when background conditions are already elevated in the absence of mining activity. When agricultural guideline values are applied to the assessment of water quality in Lawsons Creek (i.e. irrigation and stock watering), it was clear that TSF seepage would have no adverse impact on these beneficial uses.

It must also be noted that the integrated water management and supply strategy presented in RWC (2022a) introduces a higher rate of water recycling within the processing circuit via the inclusion of a paste thickener. This would reduce deposition of process chemicals with tailings. Furthermore, the increased management of the TSF decant pond, to optimise recovery and re-use of runoff that has been in contact with tailings, would further reduce hydraulic potential for seepage to occur.

Recommendation

It appears that Blackmans Gully would flow beneath the southern barrier and discharge off site, despite the potential for "impoundment" of water behind the barrier, and despite the potential for acidic runoff or neutral metalliferous drainage (NMD) from the barrier into Blackmans Gully. A contingency water management strategy is required in the event that Blackmans Gully water is contaminated by acidic runoff or NMD from the southern barrier. Implications for the site water balance, downstream creek flow impacts and Water Access Licence (WAL) requirements, may also need to be considered.

Response

Runoff from upstream clean catchments would be directed beneath the Southern Barrier via a culvert structure to ensure Blackmans Gully continues to flow (see Section 5.24.11 of RWC [2021]). The upstream outer toe of the Southern Barrier would not be constructed using NAF material identified as the high manganese sub-variant of PZ2 waste material. The volumes of this material, and the means of its identification have been detailed in Bowdens Silvers' *Response to Acid and Metalliferous Drainage Peer Review*.

As runoff from upstream clean catchments would be directed beneath the Southern Barrier, there are no licensing requirements of flow impacts and this has been accepted by DPE-Water, the NSW Government Agency responsible for such considerations.

Recommendation

Potential water quality impacts associated with process chemicals need to be quantitatively assessed and management measures developed accordingly, taking into account their toxicity / ecotoxicity and chemical behaviour, such as adsorption and decomposition rates.

Response

As the proposed Mine Site water management system is designed for full containment, it renders redundant the need for such an assessment. The proposed Mine Site water management strategy has been assessed and deemed acceptable by both DPE-Water and the EPA. The submission provided to DPE by the EPA on 19 July 2020, provides specific comment on the requirements for licensing discharge if, and when required.

Recommendation

Water management strategies for various other aspects of the project are either absent, unconfirmed or unclear / inconsistent through the documentation reviewed (e.g. sediment dams, ore stockpiles, dust suppression, flood protection for the waste rock dump). Where water management strategies are provided, they are generally focussed on managing water flows, but not water quality. Treatment of contaminated water is occasionally mentioned in passing, but no details are provided. Clear and comprehensive management strategies are required for surface water (and groundwater) to avoid over-reliance on modelling, monitoring and reactive management.

Response

Neither Bowdens Silver or WRM accept this statement as a detailed water management strategy was clearly presented in Section 4 of WRM (2022). Section 4.6 of WRM (2022) provides a detailed description of how contributing catchments are assigned a zone based on the activity within the catchment and likely water quality, whereby:

- a containment zone that would provide for full containment, to a high design rainfall event, for potentially contaminated water (i.e. TSF, WRE, open cut pits);
- an erosion and sediment control zone that would provide containment from surface disturbed catchments (outside of the containment zone) for the 5% annual exceedance probability 72-hour design rainfall event, plus an additional sediment

storage zone. Depending on water quality (i.e. total suspended sediments), this water may be released to downstream environments in accordance with limits specified in the Project's Environmental Protection License that would be issued by the NSW EPA in accordance with the *Protection of the Environment Operations Act 1997*.

- a clean water zone comprising undisturbed areas with runoff collected in basic landholder (harvestable rights) dams or diverted around disturbed catchments for discharge to downstream receivers. Clean water captured in basic landholder (harvestable rights) dams would be utilised for dust suppression.

Regarding flood protection for the WRE, during operations the lower perimeter embankment haul road would extend into the Price Creek floodplain, hence the inclusion of the flood protection bund that would provide protection for the 1% annual exceedance probability design flood event. However, as described in Advisian (2020) and the EIS, the flood protection bund and haul road would be removed during closure and rehabilitation activities. The construction materials for these elements would then be placed at the toe of the WRE lower embankment as a protective measure against scour and erosion. Whilst this indicative arrangement was provided as Figure A5.14 of the EIS, it is recognised this information may not have formed part of the documents provided for review. Figure 7.2 of WRM (2022) identifies that following closure and rehabilitation, the final WRE landform would be outside the extent of Probable Maximum Flood envelope, thus removing the need for flood protection.

Section 4 of WRM (2022) provides a comprehensive and clear strategy for surface water management that can be easily transitioned into a Water Management Plan encompassing both surface and groundwater. Section 9 of WRM (2022) provides an overview of elements for the surface water component of such a plan based on their experience in preparing them for many active mine sites with NSW regulatory approval. The groundwater component is clearly described in Section 8 of Jacobs (2022). Whilst it is recognised that Section 8 of Jacobs (2022) is not explicitly titled, it clearly details plan components. Invariably, key aspects of a Water Management Plan would include reactive management actions (i.e. trigger action response plans) but also describe the periodic review process and actions, including the regular assessment of data collected during operations. Standard practice under such a plan is for collected data to be used to refine models, verify or re-calibrate parameters and identify adaptive management actions that improve performance. Finally, such a plan would be prepared in consultation with DPE, DPE-Water and the NSW EPA with regular reporting against key performance indicators also being a key element of activities under the plan.

Recommendation

An independent review of baseline surface water and groundwater quality data is warranted to ensure that appropriate discharge limits or trigger values are established.

Response

The critical assumption underpinning the proposed water management strategy presented in all documentation is that collected runoff within the containment and erosion and sediment control zones is unsuitable for release. This forms the basis of the proposed system configuration, nominal design criteria and assessment of impacts to downstream users. This position was supported by the EPA in its 19 July 2020 submission to DPE which stated. As such, no discharge limits or trigger values are currently proposed. As clearly described in the EIS and WRM (2022), if monitoring and data collection identifies water collected in the erosion and sediment control zone is of suitable quality, the Project may discharge this water. However, this would not occur until discharge limits and trigger values are developed in consultation with the DPE and EPA. In its 19 July 2020 submission to DPE, the EPA described the process by which discharge limits could be developed and following any approval of discharge limits, Bowdens Silver accepts that such limits would be described in the Project's Environmental Protection License with discharge only occurring when discharge water quality satisfy such limits. Where trigger values are presented in the EIS, they have clearly been derived and appropriately referenced as being sourced from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

4. Proposed Post-approval Actions

The management of water, including transfers, prioritisation and collection of water quality and flow data would be a day-to-day operational activity for the Project. A program of continuous improvement would be undertaken based on the review of collected data and assessment against predicted outcomes. This program would ensure site water balance model parameters are verified and / or updated and used to re-calibrate the model. Where required, the water management strategy would be revised in response to material changes in predicted outcomes.

The water quality program would also inform any strategy whereby water collected within the erosion and sediment control zone may be released. Such a release strategy would only occur, following consultation with, and approval from, DPE and the NSW EPA. All water quality limits for discharge would be described in the Project's Environmental Protection License and no discharge would occur where these limits are not satisfied.

Prior to the commencement of mining activities Bowdens Silver would develop a Water Management Plan that would describe the ongoing program of data collection, assessment and review to inform surface and groundwater management. This Plan would be prepared by a suitably qualified and experienced person in consultation with DPE Water and the EPA and would be submitted to DPE for approval. Bowdens Silver anticipates that this plan would include (but not be limited to) the following.

- A description of the plan's objectives.
- A description of the hydrological and hydrogeological setting of the Mine.
- A description of water management zone characteristics, including.
  - A description of each zone, its identification and classification based operational activities and potential water quality of runoff.
  - A description of the design criteria for storages within each zone.
  - A description of protocols for managing water collected in each zone's water storages.
- A description of the environmental risks posed by each water management zone.
- A description of protocols for managing water collected in each zone's water storages (i.e. pumping/ transfer triggers).
- A description of water balance prioritisation for recycling and re-use.
- A description of triggers for reactive management based on the results of ongoing water level and water quality monitoring.
- Identification of the persons responsible for implementation of the plan.
- Periodic review of plan implementation including review of results of the data collection program against the plan objectives, modelled predictions and management strategy.

5. Concluding Statement

Bowdens Silver and WRM confirm that the water balance modelling undertaken for the Project is appropriate and fit for the purpose of assessing the Project. Modelled catchment yields, land use types and characteristics were developed using an AWBM calibrated to the nearest long-term streamflow gauge and parameterised based on WRM's experience calibrating models at operational mine sites in the region. The lack of long-term rainfall and climate data is not an unusual or unique situation for this Project or many others that have previously been approved. The use of SILO data is an entirely appropriate, widely adopted approach for modelling biophysical systems.

Bowdens Silver considers that the assessment presented in WRM (2022), is based on representative data which provides a clear and appropriate understanding of Project's:

- water management strategy
- water supply reliability; and
- potential impacts on downstream water users.

As such, neither Bowdens Silver or WRM agree with or accept the statement that the water balance results are preliminary.

The site water balance model prepared by WRM (2022) confirms that, based on historical climatic conditions:

- the proposed water management strategy provides effective runoff management in all zones, including high runoff scenarios modelled for uncertainty;
- the Project can be reliably supplied with water across a range of modelled scenarios, including low rainfall scenarios modelled for uncertainty; and
- the Project would result in negligible impact to downstream water users.

This response to the matters raised by Earth System confirms that the Project as presented in the *Water Supply Amendment Report* can be reliably supplied with water whilst protecting downstream water quality and without impeding the access to or availability of surface water resources for downstream users. Therefore, the Project can meet its environmental obligations with respect to water resources and its financial objectives. Further, detailed design and operational oversight of components within the water management system, including plans would ensure this system remains appropriate and effective.

6. References

Advisian – Worley Group (2020a). *Preliminary Design of PAF Waste Rock Emplacement, Oxide Ore Stockpile and the Southern Barrier – 2020*. Prepared on behalf of Bowdens Silver Pty Limited and presented as Part 16b of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

ATC Williams Pty Ltd (2020).*Tailings Storage Facility Preliminary Design – 2020*. Prepared on behalf of Bowdens Silver Pty Limited and presented as Part 16A of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

Graeme Campbell & Associates Pty Ltd (GCA) (2020). *Materials Characterisation Assessment – 2020*. Prepared by on behalf of Bowdens Silver Pty Limited and presented as Part 3 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

Jacobs Group (Australia) Pty Limited, 2020. *Bowdens Silver Groundwater Assessment. Report*. Prepared on behalf of Bowdens Silver Pty Limited and presented as Part 5 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

Jacobs Group (Australia) Pty Limited, 2022. *Bowdens Silver Updated Groundwater Assessment Report IA132500.* Prepared on behalf of Bowdens Silver Pty Limited and presented as Appendix 4 of the *Water Supply Amendment Report*.

R.W. Corkery & Co. Pty Limited (RWC) (2020). *Environmental Impact Statement – 2020* (EIS). Prepared on behalf of Bowdens Silver Pty Limited.

R.W. Corkery & Co. Pty Limited (RWC) (2021). *Submissions Report – 2021*. Prepared on behalf of Bowdens Silver Pty Limited.

R.W. Corkery & Co. Pty Limited (RWC) (2022a). *Water Supply Amendment Report – 2022*. Prepared on behalf of Bowdens Silver Pty Limited.

R.W. Corkery & Co. Pty Limited (RWC) (2022b). *Water Supply Submissions Report – 2022*. Prepared on behalf of Bowdens Silver Pty Limited.

WRM Water and Environment Pty Ltd (WRM) (2020) *Surface Water Assessment*. Prepared on behalf of Bowdens Silver Pty Limited and presented as Part 6 of the *Specialist Consultant Studies Compendium* which accompanied the EIS.

WRM Water and Environment Pty Ltd (WRM) (2022) *Updated Surface Water Assessment*. Prepared on behalf of Bowdens Silver Pty Limited and presented as Appendix 3 of the *Water Supply Amendment Report*

Appendix 1

Response to Earth Systems – Surface Water

(Total No. of pages including blank pages = 10)

Table A1
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Site Water Balance				
1	The long term daily rainfall dataset (January 1889 to December 2018) is all synthetic data from the Queensland government SILO database, as there are no original meteorological station data available (WRM, 2020).	This approach is generally considered reasonable given the lack of sufficient site data, with the following caveats: • A key limitation of the SILO data (as noted by WRM) is that it may result in some reduction in the variance of the climate record compared to the observed data. As a result, peak rainfall and drought conditions may therefore not be adequately modelled on a daily basis, and therefore the risk of uncontrolled discharge or a shortfall in water supply for the project could be under-estimated. This type of uncertainty was not addressed through sensitivity analysis. • A comparison of the SILO data with (limited) available site rainfall data indicates that monthly rainfall in the project area is on average 7% lower than the SILO rainfall data based on the regression equation presented in Figure 3.3 of WRM (2020). This does not seem to have been considered in the assessment or sensitivity analysis.	Seek clarification of the implications of under-estimating climate variance for the risk of uncontrolled discharge. Seek clarification of the implications of over-estimating site rainfall for project water supply reliability.	Excluding the TSF and 130ML turkeys nest dam, the Project's water management system provides 342ML of storage to manage runoff from disturbed areas of the Mine Site (ESC zone = 150ML, Containment zone = 192ML). This volume negates underestimation in peak daily rainfalls and the potential risk of discharge. Any longer-term variance, i.e. 3 to 5 days (or longer) would be well replicated by SILO. Figure 3.3 of WRM (2022) is not considered to imply the long-term SILO monthly rainfall is 7% lower than recorded, long-term site rainfall. Rather, this plot demonstrates the SILO dataset is consistent with the site observations.
2	WRM (2020 and 2022; Section 3.5.3) states that there are no rainfall stations located within Hawkins Creek catchment upstream of the mine site, and the available flow record is of relatively short duration. In the absence of site-specific long-term data to characterise streamflow in Hawkins Creek and Lawsons Creek, the Australian Water Balance Model (AWBM) was used to represent runoff characteristics of local catchments.	The initial statement appears to be somewhat misleading as it appears that a rainfall gauging station does exist near Hawkins Creek as mapped in Figure 3.5 (WRM, 2020 and 2022). An assessment of site runoff coefficients based on the available (albeit limited) data for the site would have been helpful as an independent check on the theoretical estimates obtained via the AWBM method.	An independent check on modelled runoff coefficients / parameters should be conducted based on available measured site rainfall and flow data for Hawkins Creek.	Figure 1.1 and Section 3.2 of WRM (2022) identifies the rainfall gauge in the Hawkins Creek catchment within the Mine Site. Section 3.5.3 of WRM (2022) correctly states there are no rainfall gauging stations upstream of Mine Site. The derived runoff coefficients were much lower than would be expected with WRM suspecting this partly due to upstream water extraction /dams. However, it is possible that it's because the site rainfall is not representative.
3	A Goldsim model was developed to simulate the operation of the water management system and "keep complete account of all site water volumes and representative water quality on a daily time step".	Water balance model results for all site water volumes were not presented. It is unclear whether each site water storage facility was modelled individually, or whether some water storages were combined for simplicity (which could potentially affect uncontrolled discharge). A water quality model was not presented for the water management system. Therefore, it has not been possible to assess whether site water is fit for purpose, to fully assess potential impacts on receiving waters (e.g. from TSF seepage), or to develop treatment or other site water management strategies. The water balance model outputs presented were averages over the mine life. Daily model outputs were generally not presented. This prevents a detailed independent assessment of the data and lowers confidence in conclusions relating to the risk of uncontrolled discharge and water supply reliability.	Water balance model results should be provided for all site water volumes, on a daily basis, throughout the mine life. A site water quality model is required to assess whether site water is fit for purpose, to fully assess potential impacts on receiving waters (e.g. from TSF seepage) and/or to develop treatment or other site water management strategies.	The difficulty to fully review the water balance model with the information presented in the EIS is acknowledged. In part this is due to balancing the provision of sufficient information for Government agencies whilst maintaining brevity for public consumption during exhibition. Percentile plots and water inventories, including the maximum envelopes of the daily results for the TSF and the open cut pit were provided as Figures 5.4, 5.5 and 5.6 of WRM (2022). Some dams were modelled as lumped storages. These can be remodelled separately but, as the dams have been sized to contain the design rainfall (i.e. fixed ratio to catchment area), the outcomes would be the same. The Project's potential impacts on the receiving surface water system has been conservatively assessed based on full capture and containment of runoff from disturbed catchments within the Mine Site and no discharge. Should discharge be proposed during operations, it would only occur from the ESC zone where water quality parameters meet those described in the Project's Environmental Protection Licence. This has been accepted by the NSW Government Agency responsible for the issuing, and compliance with, such licences, the NSW Environmental Protection Authority. ATC Williams prepared the preliminary TSF design based on a significant consequence category dam due to presence of PAF tailings. Therefore, engineered design accounts for impacted water quality within TSF. Additional TSF design elements to reduce seepage were assessed in the Submissions Report. This assessment was supported by refined groundwater modelling and solute transport modelling. Conservative mixing and dilution modelling in Lawsons Creek was also undertaken with the results presented in Table 3.1 of the Submissions Report.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Site Water Balance (Cont'd)				
4	To model catchment yield in the site water balance model, a total of 8 land use types were identified: • Lined (e.g. HDPE liner or equivalent). • Natural/undisturbed, representing areas in their current state. • Pit and hardstand (combined) which include: – Walls and floor of the open cut pit. – Pads, processing plant areas and roads. • Rock and capped combined, which include: – Placed NAF/PAF waste rock. – Soil capping layer installed over PAF waste rock placed in the WRE. • Rehab, representing fully rehabilitated/revegetated areas. • Tailings, representing tailings beach in the TSF.	The reliability of model outputs will be affected by how accurately each of these land use types are represented. Examples of land use types with different runoff characteristics include: • Different types of natural/undisturbed land, such as forested, agricultural or grazing land. • Pit walls versus pit floor rock. • Waste rock dumps before versus after capping. It is also unclear whether / how open water bodies have been modelled (e.g. TSF pond area and its effect on evaporation rates). It is unclear whether the model includes TSF seepage pump-back (for the previous and updated TSF liner designs), waste rock dump seepage (leachate dam) pump-back, or TSF seepage losses to groundwater (for the previous and updated TSF liner designs). Confidence in the model outputs is therefore limited.	Seek further clarification of the water balance modelling method and the sensitivity of model outputs to uncertainties in runoff characteristics of different land use types.	Apart from the TSF, the catchment of the Mine Site's water management system would be largely disturbed. Therefore, only a relatively small portion of this catchment is modelled as natural/undisturbed. As a result, further catchment subdivision by rural land use would be of limited benefit. WRM have assumed that Pit Walls and Pit Floor will behave similarly. WRM have modelled the uncapped and capped waste rock and capped waste rock with different parameters. Maps showing the adopted areas are provided as Figures 4.4 to Figure 4.7 of WRM (2022) with a detailed chart provided as Figure 5.2. WRM adopted runoff parameters which have successfully reproduced storage behaviour at Upper Hunter River coal mines. It is however recognised that the Project is a greenfield site in somewhat (though not entirely) different geology. Therefore, there will be uncertainty in the catchment parameters, hence the sensitivity analysis undertaken at the request of the NSW Department of Planning and Environment - Water. It is also noted that adding further complexity will not reduce uncertainty. Open water bodies have been modelled using volume vs surface area vs water level curves derived from the design information where available. In the case of the TSF, the relationships were interpolated using the fill curve and stage plans of the tailings surface at key stages of the TSF development which were provided by ATC Williams. Pumping of surface water from the TSF decant pond and the leachate management dam is included in the modelling. Additional TSF seepage pumpback is not included as it is not expected to be significant compared to the other flows due to the additional seepage mitigation design elements that reduce seepage.
5	In the absence of site-specific data, AWBM parameters for disturbed areas were adopted based on "experience with catchment modelling at upper Hunter Valley mine sites". The appropriateness of AWBM parameter values was raised as an issue during the peer review by HEC in February 2020.	Notwithstanding the concerns noted above, the AWBM parameters result in runoff coefficients that do not always appear to reflect the corresponding land cover type. Some examples include: • Lined surfaces, where the modelled runoff coefficient was only 44.6% (unclear why this is so low for HDPE lined areas). • Natural/undisturbed areas, where the modelled runoff coefficient was 4.6% despite an earlier estimate of 4.9% (Table 3.1) for the Lawsons / Hawkins Creek catchments. • Rehabilitated areas, where the modelled runoff coefficient was the same as that for place waste rock (2.7%) and notably lower than that assigned to "natural/undisturbed" areas.	Seek further clarification of the water balance modelling method and the sensitivity of model outputs to uncertainties in runoff characteristics of different land use types.	Under the high runoff scenario, WRM modelled 60% runoff from lined areas. The modelled range for lined areas (all scenarios) of 45% to 60% is expected. This is attributed to the local climate where frequent, small rainfall events contribute very little runoff to a lined storage of the TSF's size as there will be small depressions in the surface that will collect water that then evaporates. By contrast, the short-term runoff coefficients during larger rainfall events do reach 100%. The differences in runoff coefficients for Lawsons and Hawkins Creek is due to the use of different to rainfall stations in the analysis and different periods of analysis. The assessment for rehabilitated areas is representative of a relatively high infiltration into the 'store and release' cover compared to the natural conditions. The uncertainty in these values have been tested using sensitivity analysis.
6	Groundwater and surface water collected in the main open cut pit were used as the first preference for meeting site water demands (WRM, 2020 and 2022).	This appears to be inconsistent with current plans to prioritise other water sources (e.g. leachate dam, TSF decant pond) over pit water. Implications for water balance model outputs are unknown.	Seek further clarification of the water balance modelling method and any implications for model outputs.	Noted and acknowledged for checking. This statement considered to refer to any shortfalls in nett requirements after supply from the TSF decant pond.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Site Water Balance (Cont'd)				
7	The catchment area of the "Containment" system is expected to peak at 550ha, including 300ha in the TSF catchment and 250ha in the remainder of the water management system (WRM, 2020). This results in an estimated surface water runoff loss of 177ML/year.	It is unclear whether all catchment areas containing NAF waste rock, dumps are included in this estimate. If they are not included, then surface water runoff losses could be higher than 177ML/year. For example, the data in Table 4.4 (WRM, 2020) indicates a possible total catchment area of up to around 670ha if the southern barrier and lower haul road (comprising NAF waste rock) are included. Furthermore, the proposed addition of clean water harvesting (WRM, 2022) results in surface water losses from an additional 144.5ha of catchment area. This suggest that the impacted catchment area could peak at around 815ha in total, rather than 550ha as indicated, representing around 3.0% of the Lawsons Creek catchment area (272km^2). Despite the proposed amendment, there were no changes in the summary of predicted impact on mean annual streamflow in downstream waters (WRM, 2020 and 2022; Table 8.1). Implications for Lawsons Creek flow rates and Water Access Licence (WAL) requirements may need to be reviewed.	Impacts on mean annual streamflow in downstream waters need to be predicted for the proposed amendment. Implications for WAL requirements may need to be reviewed.	The 550 ha is made up of the TSF, Pit and Processing Plant catchments and the "NAF materials" catchments shown on Figure 8.2 of WRM (2022). Apart from clean water harvest sub-catchments in Blackmans Gully, runoff from the undisturbed catchment upstream of the Southern Barrier will not be contained on site. Rather it will be allowed to pass through the Southern Barrier via drainage pipes. Clean water harvesting is excluded from the catchment loss analysis as it is a basic landholder right under Section 53 of the Water Management Act 2000 with water able to be taken irrespective of Project approval.
8	The water balance outputs indicate "rainfall and runoff" as the primary inflow to the site, averaging 806ML/year between Year 1 and Year 14 of mining operations (WRM, 2020). This was updated to 856ML/year in WRM (2022).	This key model output is confusing to the reader as it suggests 806ML/year (or 856ML/year) of surface runoff would be removed from the Lawsons Creek catchment, well in excess of losses presented elsewhere in the EIS (177ML/year). If this is correct, surface water impacts will be much higher than presented in the EIS. The reason for the increase from 806 to 856ML/year is also unclear. Although not stated, this estimate may include process water from the TSF decant pond, in addition to "rainfall and runoff". Clarification of terminology / impacts is required.	Seek clarification of "rainfall and runoff" terminology in water balance outputs (which appears to be inaccurate) or update impact predictions if predicted "rainfall and runoff" is actually as high as 806ML/year (or 856ML/year).	It is noted the "rainfall and runoff" terminology is potentially confusing however it's a critical aspect to understanding the site water balance. "Runoff" is that component of the water balance where overland flow is generated from a rainfall event of sufficient magnitude. The "rainfall" component relates to the direct contribution of meteoric rainfall onto a ponded surface within a water storage (i.e. the TSF decant pond). The key reason for the difference between the 177ML/year and 856ML/year rainfall and runoff component of the water balance is that runoff rates are much higher within the disturbed Mine Site catchments (e.g. TSF and open cut pit) when compared to the existing undisturbed catchments. The increase from 806ML/y to 856ML/y is attributed to the TSF liner and addition of clean water harvesting.
9	The key sediment dams within the mine site and their associated capacities were presented in Section 4.6 of WRM (2020 and 2022).	Two alternative capacities are provided for each sediment dam. It is assumed that the smaller capacities would apply if water quality was acceptable for discharge, and the larger capacities if water needed to be retained on site, however water balance modelling appears to have been conducted only for the latter scenario. The alternative scenario (smaller sediment dams) was not modelled, but would lower water supply reliability for the project. It appears that the sediment dams for the southern barrier have not been designed to contain flows from Blackmans Gully, which lies beneath this barrier and presumably is allowed to discharge off site without treatment, despite the potential for "impoundment" of Blackmans Gully water behind the "NAF" waste rock in the southern barrier (Advisian, 2020), and despite the potential for drainage/seepage from the southern barrier into Blackmans Gully. There does not appear to be any contingency water management strategy in the event that Blackmans Gully water is contaminated by acidic runoff or NMD from the southern barrier, nor does this appear to have been considered in the water balance or assessment of downstream creek flow impacts. Finally, if Blackmans Gully water needs to be retained on site due to contamination from the southern barrier material, a WAL would be required (WAL exemptions do not apply to 3rd order streams).	Larger sediment dam sizes are supported from both a water quality perspective (lower risk of uncontrolled discharge) and a project water supply reliability perspective. Until a sediment dam sizing is confirmed, water balance modelling should be conducted for both potential scenarios (small versus large sediment dam capacities). A water management strategy is required in the event that Blackmans Gully water is contaminated by acidic runoff or NMD from the southern barrier. Implications for the site water balance, downstream creek flow impacts and WAL requirements and may also need to be considered.	Noted and correct. The proposed water management system has been devised and sized to ensure discharge from clean Blackmans Gully catchments is not affected by runoff that has been in contact with disturbed catchments. A clean water diversion would be created around the open cut pits and passed under the Southern Barrier, which is not relied upon as a water-retaining structure. Therefore, no WALs are required. This Southern Barrier drainage outlet under the Southern Barrier has been sized to ensure that water does not pond against the barrier for extended periods.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Site Water Balance (Cont'd)				
10	In the SEARs, the EPA requires "a water balance including water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options".	Water quality has not been included in the site water balance model by WRM (2020 and 2022). Proposed treatment methods have not been documented.	A site water quality model is required to assess whether site water is fit for purpose and/or to develop treatment or other site water quality management strategies.	WRM (2022) Table 5.6 presents maximum modelled storage volumes that identifies no discharge from site. Where required, water recovered from water management infrastructure will be treated for use in the processing plant. Should discharge be proposed during operations, it would only occur from the ESC zone where water quality parameters meet those described in the Project's Environmental Protection Licence.
11	A key conclusion of water balance modelling is "dam overflows" which are predicted to average 0ML/year (WRM, 2020 and 2022). From the maximum modelled volumes in Table 5.6, it appears that "processing plant dams" have been modelled collectively, as have "other combined sediment dams (modelled as containment structures)".	It is unclear whether zero discharge would still be predicted if: • Site water storage dams were modelled individually; and • The results were presented for each individual dam on a daily basis, rather than averaged over 14 years. It appears that sediment dams are included in this estimate of "dam overflows" and that their larger storage capacities were assumed.	Seek further clarification and/or request supporting data to justify this conclusion.	As noted in the response to Item 3 Some dams were modelled as lumped storages. However, they would still not discharge if separately modelled separately as the volume to catchment ratio would be unchanged.
12	The maximum modelled stored water volumes were presented in Section 5.5 of WRM (2020) and updated in WRM (2022).	The estimated TSF decant pond volumes have approximately doubled between the WRM (2020) and WRM (2022) reports. The reason for this significant change is unclear. It is also unclear why modelled evaporation rates are so similar – 440ML/year (WRM, 2020) versus 448ML/year (WRM, 2022) despite the significant increase in TSF decant pond size. It is also unclear why the maximum modelled TSF pond volume (3340ML) in Table 5.6 differs from that in Table 5.7 (3,517ML). It is unclear why maximum modelled water volumes are not presented for the Turkeys Nest (130ML capacity) in Table 5.6.	Seek further clarification of these water balance model outputs.	The TSF liner arrangement and tailings solids content has been amended since WRM (2020). Therefore, modelling of the full liner and filling rates/TSF surfaces and shape have changed. The Turkeys Nest Dam is operated full, with an operating level chosen to allow freeboard for the maximum direct rainfall on the surface so that it never overflows. The dam would be designed with an operating level set to achieve this.
13	The sensitivity analysis for the water balance model considered 2 sets of AWBM parameters to reflect "low runoff" and "high runoff", as shown in Table 5.8 and 5.9 of WRM (2020 and 2022). A further sensitivity analysis was conducted in which groundwater inflows were assumed to be half the predicted values.	Notwithstanding previous concerns relating to modelled runoff coefficient values, for the "low runoff" scenario modelled average runoff coefficients were higher for "waste rock emplacement", "rehabilitation" and "lined" land use categories, in comparison with values used for the original model. This seems to be at odds with a "low runoff" scenario and could result in over-estimation of water availability for the project. Furthermore, the sensitivity analysis conducted to date is limited, with no consideration of: • Low or high rainfall scenarios. • Under-estimation of variance in the SILO data. • Lower rainfall measured at site relative to corresponding SILO data (e.g. on average 7% lower rainfall as noted above). • Evaporation. • Other key model input variables. • Cumulative sensitivity associated with multiple parameters (not just sensitivity analysis of one parameter at a time).	Seek clarification of the sensitivity of the model to other key input variables, and implications for the risk of uncontrolled discharge or project water supply reliability.	Errors reported in these tables are acknowledged and will be identified and clarified. However, the similar runoff parameters for the "waste rock emplacement", "rehabilitation" and "lined" in the low runoff and base case scenarios parameters are considered justifiable as the different runoff coefficients were very low to start with. Refer Item 1 for response on site vs SILO rainfall data. High and low rainfall scenarios have been modelled via the wet and dry periods included in the 130-year SILO dataset year).

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Site Water Balance (Cont'd)				
14	A key output of water balance modelling is "annual increase in stored volume" which are predicted to average 41ML/year (WRM, 2020). This was updated to 31ML/year (WRM, 2022).	The average value reported is equivalent to 574ML (2020 estimate) or 434ML (2022 estimate) of water accumulating in site water storages over 14 years. It is unclear what the "stored volume" actually refers to and how this excess water would be managed.	Seek further clarification of what the "stored volume" actually refers to and how this excess water would be managed.	Annual increase in "stored volume" is the volume in all storages at the end of the simulation period minus the sum of the volume at its commencement (zero in this case). The water balance predicts a small average annual excess of inflow over outflow. Therefore, on average the water balance predicts a small volume of water remaining in storage at the end of the simulation. To expedite equilibrium final void pit lake water levels and allow TSF decommissioning/rehabilitation, the water balance model transfers excess water from the TSF decant pond to the open cut pit at the cessation of operations.
15	In the updated water balance model (WRM, 2022) water requirements for haul road dust suppression have been significantly lowered (from 204ML/year to 131ML/year on average) "based on experience at nearby operations".	No supporting data were provided. No information on the proposed chemical composition has been provided, nor application rates or toxicity.	Seek clarification of the implications of under-estimating water requirements for dust suppression for project water supply reliability.	The reduction has been derived from recent usage metering at a nearby upper Hunter Coal mines before and after utilisation of a proprietary dust suppressant.
16	For the proposed amendment, water supply reliability was estimated at (WRM, 2022): • Processing plant (average 99.4%; low 94.5%). – For a "low runoff" scenario this decreased to 98.4% (average) and 90.0% (low). – For a low groundwater inflow scenario this decreased to 86% (average) and 65% (low). • Dust suppression (average 99.8%; low 99.5%).	Despite only 86% reliability on average under a low groundwater inflow scenario (and 65% in the worst case scenario modelled), the implications for mine operations were discussed only briefly (Corkery, 2022) and it was noted that "Bowdens Silver does not consider this a risk to the financial viability of the Project". Sensitivity analysis was not conducted for dust suppression water supply reliability, which could also be affected by uncertainty in runoff coefficients and groundwater availability. Water supply reliability could be over-estimated (see comments above relating to analysis for the water balance model).	Seek clarification of the project viability and the sensitivity of water supply reliability estimates to uncertainties that have not yet been modelled.	Bowdens has weighed up the magnitude and duration of the loss of production in deciding what is commercially sustainable for the Project. Jacobs (2022) predicted groundwater availability (open cut pit inflows and advanced dewatering) using a "fit for purpose" groundwater model that was calibrated to local conditions. Therefore, the low groundwater inflow scenario tested by WRM in the site water balance, is unlikely to eventuate. However, groundwater contributions are always predicted to be available and therefore critical operations could be sustained for a period, especially with water savings measures in place.
Final Pit Void Water Balance				
17	The main open cut pit would be left as a void covering ~53ha and allowed to progressively fill largely with groundwater as surface water would be diverted around the void (EIS Section 2.13.3). WRM (2020) states that "following completion of the final raise, when the cell reaches its maximum height, the top section of the cell would be reshaped, capped and covered to drain back towards the main open cut pit". The same report later states that "all upslope catchments will be diverted around the final void".	It is unclear whether waste rock dump drainage will be directed to the main pit. This could significantly affect the final pit void water balance model outputs.	Seek clarification of the final pit void catchment area and whether this includes waste rock dump runoff.	Figure 7.2 of WRM (2022) identifies clean water diversion drains around eastern edge of open cut pit that would prevent upslope runoff from rehabilitated WRE from entering the final void. With the proposed diversions in place, the WRE does not drain to the final void and its external catchment is minimal.
18	Groundwater inflow was predicted to peak in Year 4 (1,066ML/year), with a daily peak of ~3.5ML/day and average of 2.4ML/day (although only ~1.75ML/day would reach the pit sump due to evaporation losses from the pit walls (EIS Section 4.6.5.3).	This indicates an evaporation loss of 27% from the pit walls. Elsewhere reference is made to an evaporation loss of 20% from the pit walls (WRM, 2020 and 2022; Section 4.3). The reliability of pit wall evaporation losses is unclear, but model outputs could be highly sensitive to this.	Seek clarification of the sensitivity of modelled water levels in the final pit void to pit wall evaporation rates.	Noted
19	The storage evaporation factors for pit lake water used as model inputs ranged from 0.5 (bottom of void) to 0.8 (top of void) as outlined in Section 7.7 of WRM (2020). The "top of void" factor was subsequently updated to 0.95 (WRM, 2022). Sensitivity analysis was conducted including: • Reducing the evaporation factor to 0.7 (WRM, 2020) or 0.8 (WRM, 2022) at the top of void. • Modifying AWBM parameters to increase runoff to the void). • Increasing groundwater inflows by a factor of 1.5 or 2.0.	No justification was provided for the original storage evaporation factors (WRM, 2020) or the changed "top of void" factor (WRM, 2022). This is despite the significant difference in pit evaporation losses predicted for the "existing" climate scenario (295ML/year predicted in 2020 versus 325ML/year predicted in 2022). The sensitivity analysis demonstrates significant uncertainty in the final pit lake water level, which would peak at 587.3mAHD (WRM, 2020) or 583.7mAHD (WRM, 2022) under the worst-case scenario modelled. It is unclear why the "increased" groundwater inflow rates (49.7ML/year and 52.2ML/year) are much lower than the reported groundwater inflow rate of 76ML/year WRM (2020; Table 7.3). In the 2022 update, the "increased" groundwater inflow rates were much higher (87ML/year and 95ML/year) and yet comparable to the "average" of 92ML/year (WRM, 2022; Table 7.3).	Seek clarification of the sensitivity of modelled water levels in the final pit void to groundwater inflow rates.	The storage evaporation factors were derived from the results of monitoring of evaporation from coal mine voids at various locations in NSW and Queensland for the ACARP spoil hydrology project. https://www.acarp.com.au/abstracts.aspx?repId=C7007 Groundwater inflow rates are reduced by pit lake water level rises.

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Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Final Pit Void Water Balance (Cont'd)				
20	The modelled outputs for the "existing" climate scenario changed significantly from WRM (2020) to WRM (2022) despite the same rainfall and evaporation input data.	It is understood that an error in the 2020 model was identified and rectified for the 2022 model, however no explanation of this change was provided in the 2022 report. The reason for different groundwater inflow rates for the "existing" climate scenario (76ML/year predicted in 2020 versus 92ML/year predicted in 2022) is unclear. A detailed review of the water balance data would be required to better understand these issues.	Conduct detailed review of the water balance data to better understand these issues.	WRM inadvertently enabled unscheduled timesteps in the final void model water balance model which introduced surprisingly high errors in the incorporated AWBM runoff model (which is strictly a daily timestep model). Figure 7.4 of WRM (2022) identifies decreasing groundwater inflows with increasing pit lake elevation that reduces to 0 at approximately 590mAHD. The increased groundwater inflows at equilibrium of WRM (2022) reflect lower final void pit lake water level at equilibrium.
21	On the basis of the final void water balance model, the pit lake would not overflow to the surface and remain a groundwater sink post-mining (WRM, 2020 and 2022).	This statement ignores the possibility of seepage towards Hawkins Creek post-mining and potential implications for receiving water quality. The sensitivity analysis in WRM (2022) indicates pit lake water levels up to 583.7mAHD, well in excess of the elevation at which the pit lake would transition from a "sink" to throughflow conditions, which is ~579mAHD (Jacobs, 2022). Indeed, the Response to Submissions (Corkery, 2021) refers to post mining water table contours (Jacobs, 2021) which indicate a gradient from the pit lake towards Hawkins Creek, with a potential groundwater travel time in excess of 100 years.	Conduct a quantitative assessment of the potential impacts of pit lake water migration through groundwater on receiving surface waters.	The possibility has not been ignored and is the subject of the groundwater assessment. Note: Jacobs have reviewed implications on groundwater model calibration when model parameters are altered to result in the 1.5 and 2.0 times groundwater inflows assessed by WRM. This required increases to hydraulic conductivity values between 8 and 20 times that of the calibrated model and resulted in scaled root mean square errors 2.3 time and 2.9 times (respectively) greater than that achieved for the calibrated groundwater model. Therefore, the inflow scenarios adopted by WRM are improbable.;
Water Management				
22	Water quality issues and management implications relating to sulfidic mine materials and the potential for acid and metalliferous drainage (AMD) or neutral metalliferous drainage (NMD) were reviewed in Earth Systems (2022).	*Refer to comments in Earth Systems (2022).*	*Refer to recommendations in Earth Systems (2022).*	
23	In the SEARs, the EPA requires a water quality monitoring program and response management plan.	This has not yet been provided in the EIS or more recent documentation.	A water quality monitoring program and response management plan is required.	Section 9.2 of WRM (2022) describes the approach to water quality monitoring during operations. The NSW Environmental Protection Authority has not raised this matter following review of all documentation. Bowdens continues to undertake water quality monitoring
24	Table 2.4 of the EIS identifies processing plant reagents including hydrated lime / soda ash, copper sulfate, MIBC, sodium cyanide, flocculant, lead collector, zinc collector, caustic soda and antiscalant. The fate of these is generally assumed to be tailings, if not concentrate, with some decomposition of chemicals such as MIBC and NaCN. In contradiction to this, the EIS also states that the bulk of the chemical reagents would report to the produced silver/lead and zinc concentrates.	This discrepancy is also acknowledged In the Response to Submissions (Corkery, 2021) but dismissed as an issue on the basis of the small tonnages of chemicals relative to tonnages of tailings. The fate of process chemicals remains uncertain. Furthermore, Corkery (2021) incorrectly states that zinc and copper are non-toxic. No assessment of potential water quality impacts, or management implications, associated with process chemicals was conducted. The toxicity and ecotoxicity of process chemicals, and implications for OHS and the receiving environment have not been considered. The chemical behaviour, such as adsorption and decomposition rates, have not been considered in any detail.	An assessment of potential water quality impacts associated with process chemicals is required, with management measures developed accordingly.	Process water not reclaimed during paste thickening would report to the TSF. ATC Williams prepared preliminary TSF design based on significant consequence category dam due to presence of PAF tailings. Therefore, engineered design accounts for impacted water quality within TSF. Additional TSF design elements proposed in Submissions Report to reduce seepage.
25	Allowance has been made for 4 years for TSF rehabilitation works and 3 years for maintenance, but it is also acknowledged that relinquishment would only occur "once revegetation satisfies the requirements of the Resources Regulator and leachate generation from the WRE ceases" (EIS Section 2.13.3). It is later stated that "no time limit would be placed on post-mining rehabilitation monitoring and maintenance".	The status of TSF seepage at the time of relinquishment is not mentioned, but indications are that this could occur over 200 years (EIS Section 4.6.5.3). There is no strategy for TSF seepage flow / water quality management during this time. The potential for long term ongoing seepage from the waste rock dump has not been considered or assessed. The proposed rehabilitation monitoring and maintenance program (EIS Section 2.16.7) refers to ongoing monitoring for "evidence of any acidic runoff" but doesn't consider the possibility of acidic seepage (nor other potential long term water quality issues).	A strategy for TSF and waste rock dump seepage flow / water quality management post-closure is required.	ATC Williams prepared preliminary TSF design based on significant consequence category dam due to presence of PAF tailings. Therefore, engineered design accounts for impacted water quality within TSF. Additional TSF design elements proposed in Submissions Report to reduce seepage. Reactive transport modelling report prepared. The closure capping design includes measures to prevent ingress of meteoric water entering stored PAF materials. Water quality and flow into leachate management dam is therefore expected to reduce over time. The WRE would be a HDPE lined facility with seepage not anticipated.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Water Management (Cont'd)				
26	Potential impacts on groundwater quality associated with the open cut pit lake and tailings were dismissed in the EIS (Section 4.6.7.4) as follows: • Pit lake impacts were dismissed on the basis of the lake acting as a groundwater sink, preventing discharge of saline water to the regional groundwater system. • Tailings impacts were dismissed on the basis of assumed tailings pore water salinity / pH / metal concentrations and the assumption that any impacts would be localised to areas of groundwater mounding and not extend beyond 40 metres from the mine site boundary. It is stated that pit water quality "would generally reflect the quality of the combined natural groundwater and surface water inflows to the pits" (EIS Section 4.7.4.4) and that salinity would increase over time only due to evaporative concentration (EIS Section 4.7.5.6).	The risk of pit lake water throughflow towards Hawkins Creek (see above), and the potential for AMD in pit water (Earth Systems, 2022), needs to be considered and impacts on receiving water quality assessed. This also needs to consider potential contaminants in pit water from other sources (e.g. leachate dam, TSF, process water). As a result, no pit lake water quality management strategy has been developed. Predicted tailings pore water quality is based on leachate test work conducted by GCA (2020) and does not consider the risk of AMD generation from PAF tailings (Earth Systems, 2022), nor does it consider the addition of other contaminants from the mine site / process plant water, or the potential for concentration of contaminants due to water re-circulation (see earlier comments regarding site water quality modelling). The prediction of no groundwater quality impacts beyond 40 metres of the mine site boundary was not justified. Solute transport modelling was subsequently conducted for the TSF (Corkery, 2021) and indicates that: • The modelled solute concentrations at Lawsons Creek exceed water quality guidelines for some parameters (e.g. copper, zinc, cyanide and phosphorus) even under the currently proposed TSF Design Option 1 which will substantially lower seepage concentrations relative to the previous design presented in the EIS. • Modelled solute concentrations in groundwater (BGW16 and BGW17) were also elevated relative to background concentrations and guideline values for copper, cyanide and phosphorus, presented in Table 3.1 of Corkery (2021). • Even poorer water quality could be expected in the modelling allowed for the potential impacts of AMD from PAF tailings (Earth Systems, 2022). Despite the clear risk to receiving water quality in Lawsons Creek, no clear management strategy was presented to address this. A commitment was only made to conduct "reactive transport modelling to further quantify the geochemical processes and natural attenuation of potential seepage from the TSF to inform detailed design". Reliance on optimistic outcomes of future modelling is not sufficient given the risks already identified.	A comprehensive pit lake water quality assessment and management strategy is required. A comprehensive TSF seepage quality management strategy is required.	Modelling identifies the final void pit lake will remain a groundwater sink with water levels well below the pit rim. Refer response to Item 25.
27	It is stated that "for cyanide, it is proposed that the WAD cyanide concentration in the tailings pumped to the TSF would be approximately 7mg/L", with 10mg/L nominated as a safe level for fauna.	No management strategy for cyanide has been presented, in the event that WAD cyanide concentrations exceed this "safe level".	A management strategy for cyanide is required.	The use of sodium cyanide is regulated in NSW through the Protection of Environment Operations Act 1997 that is administered by the NSW Environment Protection Authority. Cyanide concentrations in tailings discharge is regulated at many NSW mine sites via Environmental Protection Licences issued by the Environment Protection Authority. Section 5.9.3 of the Submissions Report identifies a Cyanide Management Plan would be prepared for the Project post-approval. This plan would describe the measures to maintain cyanide levels in accordance with any Environmental Protection Licence issued for the Project.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Water Management (Cont'd)				
28	The EPA requires that "where the management of sediment basins requires the use of flocculants, the EIS should include information about the type, toxicity and management of flocculants proposed to treat captured water before discharge".	This information has not been provided.	This information needs to be provided in advance of any off site discharge from sediment basins.	Noted and agreed, however discharge of this water is not currently proposed.
29	In the Response to Submissions (Corkery, 2021; Section 5.11.19) it is noted that the methodology used to assess groundwater quality statistics has been reviewed and updated statistics are provided in Jacobs (2021).	This raises the question of whether surface water quality statistics also needed to be updated, and whether this has any implications for the impact assessment results and management requirements. Any changes to baseline data statistics could also affect future site discharge limits or trigger values for monitoring data.	Seek a detailed independent review of baseline surface and groundwater quality data to ensure that appropriate discharge limits or trigger values are established.	The changes noted reflect the substitution of data values where laboratory analyses recorded results below the limit of reporting. However, the Project is not proposing water quality trigger values based on baseline data. Baseline water quality data has been used to inform mixing and dilution modelling to assess impacts of TSF seepage in baseflow contributions to Lawsons Creek. However, adoption of a substituted data value, where none has been recorded in analyses, reduces the values derived from statistical analyses. This in turn increases the assimilative capacity of the receiving system being assessed. In the absence of discharge, ANZG aquatic ecosystem trigger values (95% species protection for slightly to moderately disturbed ecosystems) would be adopted for comparison of ambient surface water quality monitoring data.
30	The surface water management strategy comprises 3 main zones, according to expected water types and management requirements: • Clean water zone. • Erosion and sediment control (ESC) zone. • Containment zone.	Surface water management strategy is unclear as the ESC and Containment zones both appear to include "NAF" waste rock stockpile runoff. The fate of sediment dam water appears to depend on whether it is suitable quality for off site discharge and is therefore uncertain (EIS Section 2.10.1, Section 4.7.4). It is assumed that the sulfidic ore stockpile drainage (a potential source of AMD) forms part of the Containment zone but this is unclear.	A clear strategy is needed for management of "NAF" waste rock stockpile runoff, as well as sulfidic ore stockpile runoff, and the site water management system updated to reflect this.	Section 4.6 of WRM (2022) describes the Mine Site water management strategy with NAF and oxide ore stockpiles situated within the ESC zone. The containment zone would also include some NAF that would be used as construction materials. Whilst release of water from the ESC zone has been considered and described in reporting, all site water management infrastructure has been sized to provide containment should quality of stored water be impaired. Table 5.6 of WRM (2022) presents maximum modelled storage volumes that identifies no discharge from site.
31	The executive summary of WRM (2020) states that if water quality is found to be unsuitable for release during operations, sediment dams would be dewatered and the water used for dust suppression. The same report (Section 4.5) later states that this water would actually either be treated prior to release, or recycled in mine site applications.	These statements appear to contradict each other and need to be clarified. Use of contaminated water for dust suppression should be avoided.	A clear strategy is needed for management of sediment dam water. Use of contaminated water for dust suppression should be avoided.	WRM (2020) has been superseded by WRM (2022) which should be the point of reference for the assessment of the Project. WRM (2022) notes that clean water collected from undisturbed catchments and groundwater from advanced dewatering (production) bores would be used to meet dust suppression demand. However, some ambiguity in the reporting is recognised and water for dust suppression would only be sourced from clean water or advanced dewatering (production) bores. The use of contaminated water within the containment zone (e.g. within the open cut pit) poses no risk of offsite discharge
32	It has been stated that water for haul road dust suppression was to be drawn from: • The Oxide Ore Dam as a first priority and then from the processing plant dams or Turkeys Nest Dam, if required (WRM, 2020). • Clean water dams or advanced dewatering bores (WRM, 2022) • Sediment dams (WRM, 2020 and 2022).	These statements appear to contradict each other and need to be clarified. Use of contaminated water for dust suppression should be avoided.	Clarification is required on the source/s of dust suppression water. Use of contaminated water for dust suppression should be avoided.	Refer response to Item 31.

Table A1 (Cont'd)
Response to Earth Systems – Surface Water

Item	Review Finding	Earth Systems Comment	Recommendation to NSW DPE	Response/Clarification
Water Management (Cont'd)				
33	Post-closure flood modelling was conducted to assess peak velocities along Price Creek adjacent to the waste rock dump. The surface water assessment (WRM, 2020) indicates that the embankment crests of the waste rock dump and leachate management dam are above the water level of the PMP design event. The waste rock dump design report (Advisian, 2020) indicates that flood protection bund design for the waste rock dump is based on events up to a 1:100 AEP flood.	These statements appear to contradict each other and need to be clarified. A PMP design event rather than 1:100 AEP design event is considered more appropriate for permanent landforms such as the waste rock dump, given the potential physical stability / water quality implications. Flood modelling results are presented in WRM (2020) for a 1% AEP, with some additional discussion of events up to a 0.2% AEP. It is conceivable that floodwaters could come into contact with PAF material in the base of the waste rock dump. The potential for erosion of the waste rock dump was considered, but implications for flood water quality were not specifically discussed.	Flood protection for permanent landforms should be based on a PMP design event. Consideration should be given to the potential implications for both flood water quality and stability of the waste rock dump.	During operations, the lower perimeter embankment haul road would extend into the Price Creek floodplain, hence the inclusion of the flood bund. Upon closure, the flood bund and haul road would be removed and the material placed at the toe of the WRE lower embankment. This indicative arrangement is provided as Figure A5.14 of the EIS and it is recognised this may not have formed part of the documents provided for review. Figure 7.2 of WRM (2022) identifies the final WRE landform would remain beyond the extent of PMF envelope.
34	The waste rock dump design report (Advisian, 2020) indicates that flood protection for the waste rock dump would be removed during rehabilitation and closure. The surface water assessment (WRM, 2020; Section 6.2.2) indicates that rock protection installed along the toe of the haul road embankment would be retained.	These statements appear to contradict each other and need to be clarified.	Clarification is required on the long term flood protection strategy for the waste rock dump.	Refer response to Item 33 above.