Kidston Pumped Storage Hydro Project
Genex Power Limited
01-Mar-2019

IAR Supplementary Information

IAR Supplementary Information

Client: Genex Power Limited

ABN: 18 152 098 854

Prepared by

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			Name/Position	Signature
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1.0 Introduction

1.1 Background

AECOM Australia Pty Ltd (AECOM) has prepared an Impact Assessment Report (IAR) on behalf of Genex Power Limited (Genex) for the purpose of assessing the impacts of water releases from the Kidston Pumped Storage Hydro Project (the Project) in support of an approval application. The final IAR was submitted 11 January 2019 (AECOM, 2019).

The Coordinator-General declared the Project a Coordinated Project under the Queensland State Development and Public Works Organisation Act 1971 (SDPWO Act) on 28 September 2018 for which an IAR is required. The primary activity for which an approval is being sought under the Coordinated Project process is for the water discharges as a result of excess water following significant rainfall events during operation, and to allow the lowering of water levels to facilitate construction of the Project.

Release of mine-affected water is a common practice across Queensland for a range of activities. This activity is typically managed through a range of management and monitoring requirements in line with industry standards prescribed under the Environmental Protection Act 1994 and regulated by the Department of Environment and Science (DES). Industry standards include model mining conditions (ESR/2016/1936) and the Technical Guideline for water release to Queensland waters (ESR/2015/1654).

Coupled with the reasons driving the need for a Coordinated Project declaration (the strategic significance of the Project and the lack of a defined approval process), the relevant existing practices and industry standards, the ‘fit for purpose’ IAR process was considered to be the most appropriate for the Project.

1.2 Purpose of the Supplementary information

This supplementary information has been prepared in response to comments on the final IAR received from DES on 29 January 2019 (refer to Appendix A of this Supplementary information). It also sets out the results of additional surface water sampling undertaken in February 2019, the scope of which was discussed and agreed with DES. This report should be read in conjunction with the final IAR. Capitalised and defined terms in this report have the same meaning as in the final IAR.

2.0 Responses to Comments

2.1 Executive Summary

Response 1

Section:

Executive Summary

Review Comment:

DES has previously commented on the lack of evidence in the IAR to support the assertion that Middle Spring is not hydraulically connected to the groundwater regime of the proposed release area. In response, the proponent has agreed to assess potential connectivity as part of "water modelling refinement and design phase work", however, this information should be provided in the IAR.

Recommendation:

Update the IAR to include evidence to support the assertion that the Middle Spring is not hydraulically connected to the proposed release area groundwater regime. In the absence of this evidence, hydraulic connection between Middle Spring and local groundwater should be assumed.

Recent field sampling undertaken on 19 February 2019 included water sampling from Middle Spring. The water samples were compared to (i) water previously collected from the Wises Pit, (ii) water associated with the tailings storage facility (e.g., seepage) and (iii) groundwater to the west of the site, to establish whether the water chemistry indicated an impact associated with a hydraulic connection between the pits and Middle Spring. Middle Spring major ion concentrations display very little evidence of impact from either the pits or the tailings storage facility, with the spring sample similar in concentration to the unimpacted groundwater monitored to the west of the site facilities (Figure 1).

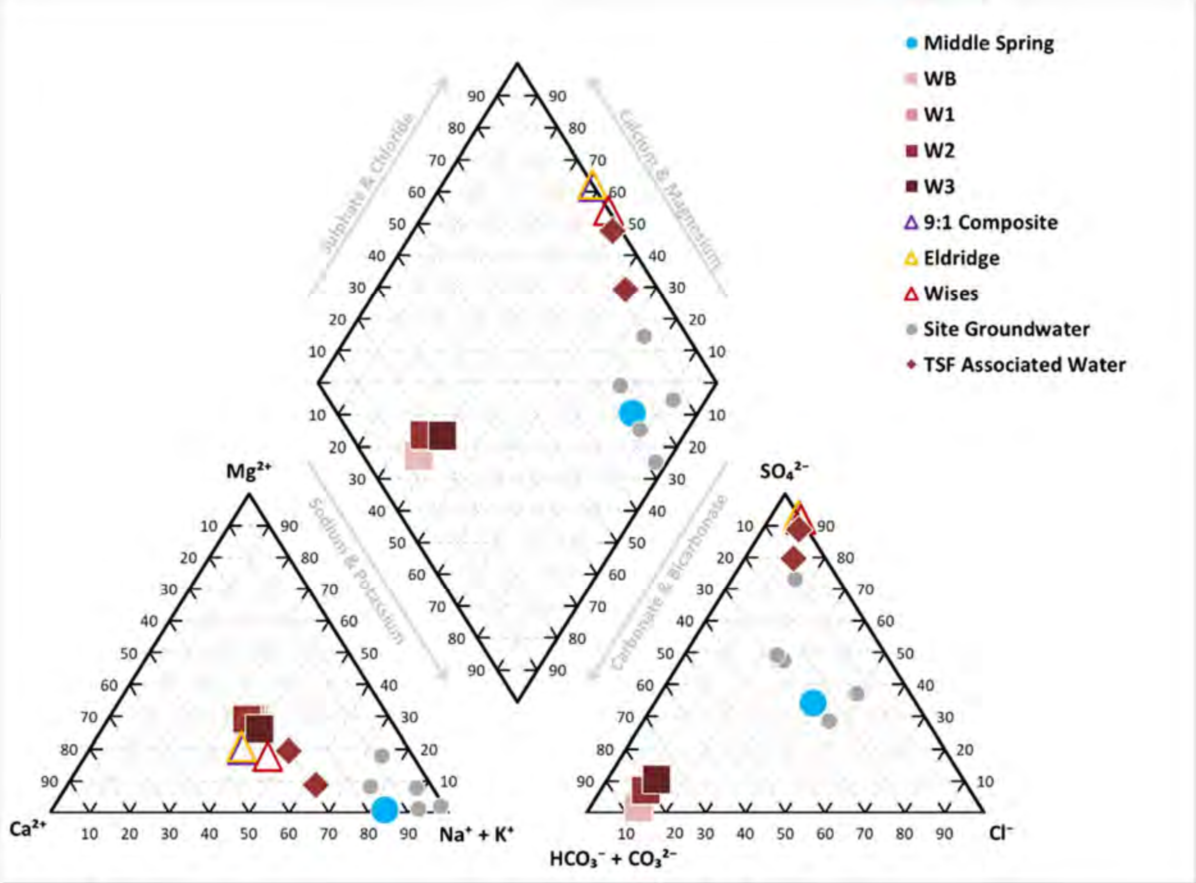


Figure 1 **Major ion concentrations (in meq/L) of the Middle Spring water sampled in February 2019, compared to water associated with the site facilities and monitored groundwater**

A groundwater assessment undertaken by AGE in January 2019 and attached in Appendix E reviewed the potential impacts of the Project on Middle Spring (SPR482), the model assuming that a connection between the pits and the spring may be possible. The spring is located approximately 4.8 km west-northwest of the Project which is a significant distance, and close to the edge of the model domain. The modelling showed that Middle Spring, if connected, would be predicted to be impacted by less than 0.2 m based on a very conservative steady state assessment. This is illustrated in Figure 7 of the AGE assessment (see Appendix E).

In summary, the groundwater modelling, which is conservative and assumes 'worst-case' conditions, predicts that the pits are unlikely to be hydraulically connected to Middle Spring. This is consistent with the recent water quality analysis, which shows that Middle Spring has not experienced groundwater influx from the pits in the years since the mine site operations ceased. It is therefore highly unlikely that the Project activities will cause an adverse impact at Middle Spring.

Response 2

Section:

Executive Summary

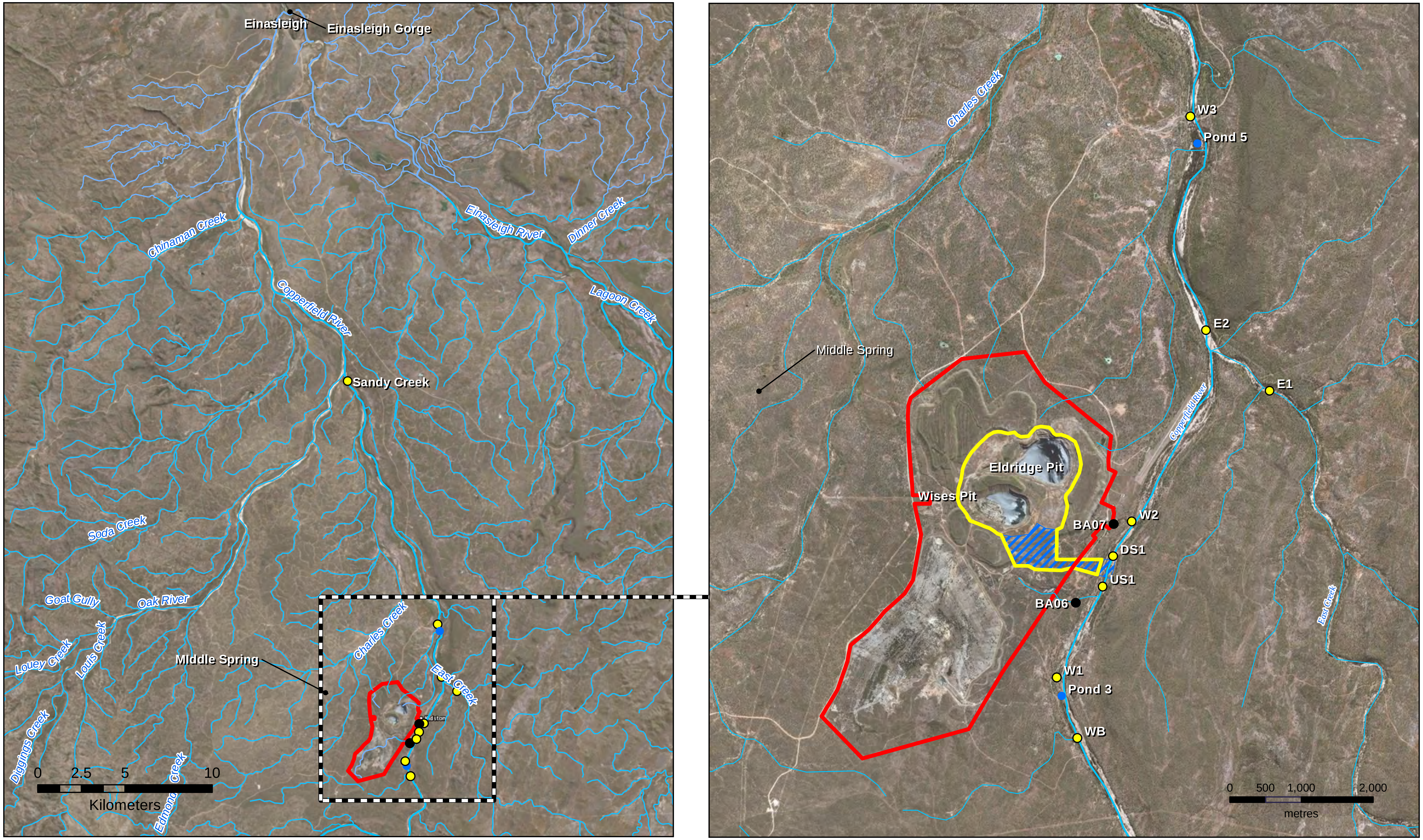
Review Comment:

The location of many features referred to in the Executive Summary is unclear in the absence of a map, for example Chinaman Creek.

Recommendation:

Include a map in the Executive Summary or the front end of the document to clarify the location of features discussed in the Executive Summary.

Figure 17 of the IAR includes locations of all relevant waterways. An additional overview of significant features which can be viewed in conjunction with the Executive Summary is presented in Figure E1 below.



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DATUM GDA 1994, PROJECTION MGA ZONE 55

LEGEND

- ● Groundwater Bore
- ● Monitoring Point
- ● Pond
- — Watercourse - Major
- — Watercourse - Minor
- ▭ Mining Lease Boundary
- ▭ Key Project Infrastructure Footprint
- ▨ Spillway Options Corridor
- Permanently active spring
- Intermittently active spring

Data sources:

Base Data: (c) 20XX (data source) (additional data)

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Overview of Important Locations

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	XX- 26 Feb 2019
VERSION:	1

Map

E1

Response 3

Section:

Executive Summary

Review Comment:

The IAR states that "In reality the actual assimilative capacity usage will be lower than 76.3% in most cases." The IAR should present a realistic summary of likely releases.

Recommendation:

Amend the IAR to provide a realistic summary of construction releases.

The 76.3% usage of assimilative capacity for the construction phase is based on the maximum concentration of dissolved zinc in Eldridge Pit and therefore represents a worst-case scenario unlikely to eventuate in reality. Assimilative capacity usage associated with other release concentrations is presented in Table 1. The assimilative capacity usage associated with the median concentration of dissolved zinc in Eldridge Pit is approximately 30%.

Table 1 Assimilative capacity usage for various release concentrations during construction

Scenario	Dissolved Zinc Release Concentration	Assimilative Capacity Utilisation
Maximum dissolved zinc concentration in Eldridge Pit	1.750 mg/L	76.3%
Maximum dissolved zinc concentration in 9 parts Eldridge to 1 part Wises mix	1.587 mg/L	69.0%
80th percentile dissolved zinc concentration in Eldridge Pit	0.745 mg/L	57.2%
Median dissolved zinc concentration in Eldridge Pit	0.688 mg/L	29.9%
Median dissolved zinc concentration in 9 parts Eldridge to 1 part Wises mix	0.630 mg/L	27.4%

Source: Table 87, AECOM, 2019

Response 4

Section:

Executive Summary

Review Comment:

The 4th dot point in this section discusses the sensitivity of the Copperfield River macroinvertebrates communities to environmental change, however, there is little discussion of why then these sensitive communities are not predicted to be impacted by operational water releases.

Recommendation:

Include additional information detailing why sensitive macroinvertebrate communities will not be impacted by operational releases.

The reference to sensitivity of macroinvertebrates communities is clarified below, in context of being an appropriate indicator organism and not in context of being a protected species.

As outlined in the REMP it is proposed to monitor water quality, sediment quality, groundwater quality, aquatic flora and aquatic fauna (macroinvertebrates) to determine risks of impacts from the Project under multiple lines of evidence.

The sensitivity of macroinvertebrate families to environmental change was determined based on their SIGNAL grade (Chessman, 2003). Toxicity data for each potential contaminant relevant to each sensitive family is not widely available; therefore sensitivity within the report is discussed in generalised terms and broadly in relation to environmental change.

Sensitive macroinvertebrate families are generally those from the orders Plecoptera, Ephemeroptera and Trichoptera (PET) families. The point made in the Executive Summary refers to these families, rather than the whole macroinvertebrate assemblage/community. The presence of sensitive macroinvertebrate families in the receiving environment (as outlined in the 2018 Aquatic Ecology assessment by C&R Consulting) indicates that the current environment is in relatively good health as these sensitive families are present within the community. Further, the sensitivity of the macroinvertebrate community to environmental change make them an ideal monitoring tool for determining if releases from the site have impacted the aquatic ecology values of the receiving environment. If these sensitive families are absent, or their abundance is decreased, downstream of the release point it would indicate that there was some form of impact occurring in the receiving environment that is impacting the overall health of the waterway. Hence, ongoing monitoring of macroinvertebrate communities as part of the REMP is proposed to gauge any impacts from the project. The presence of these sensitive families will ensure that impacts are more likely to be detected.

For example, if relevant WQOs are being met by the proposed release regime yet there was a significant decrease in the abundance of sensitive macroinvertebrate families at downstream sites compared to upstream sites, it may indicate that the WQOs are not sufficient to protect Aquatic Ecosystem EVs. Conversely, if WQOs are exceeded as a result of the release regime, yet there was no significant difference in the abundance of sensitive macroinvertebrate families downstream compared to upstream, then it could be argued that the assimilative capacity of the receiving environment was higher than what is suggested by the default WQOs, meaning that there is no actual impact to Aquatic Ecosystem EVs.

2.2 Activity Description

Response 5

Section:

Section 4.1.1 Release Infrastructure

Review Comment:

Table 2 details that "releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises". However, Table 81 [*Table 83 in final version of IAR*] only details releases to the river from Eldridge pit.

Recommendation:

Provide details/clarity around when releases during construction will occur from a mixed scenario, and how a 9:1 mixture would be achieved prior to commissioning.

The IAR has considered releases from both the Eldridge Pit directly (the most likely scenario during the construction phase), or a mixture of 9 parts Eldridge water to 1 part Wises (the most likely scenario during the operations phase).

As discussed in Table 2, during the construction phase, water will initially be sourced from the Eldridge Pit only. This will continue until the final stage of dewatering of the Eldridge Pit has been completed and construction of the tailrace works has commenced. For the remainder of the construction phase releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises.

During operation, when a mixed release is predicted to occur, the Wises Pit will have received water from Eldridge Pit and natural mixing of these waters would have occurred throughout the transfer period.

Response 6

Section:

Section 4.1.1 Release Infrastructure

Review Comment:

This section does not describe the rationale for the location of the release infrastructure.

Recommendation:

This section should clearly describe why this release location was chosen. Describe how this location maximises the avoidance and mitigation of potential impacts to environmental values of the land and Copperfield River.

The proposed location of the release infrastructure was mainly driven by physical and heritage constraints. Most of the alignment falls within a landscape that has been modified by the historic mine operations. At this stage of design, a corridor of approximately 200 m has been nominated for the discharge infrastructure to be located.

The proposed alignment corridor follows the topographical constraints, and avoids the heritage listed Kidston Township overlay. Additional cultural heritage surveys have been undertaken to confirm cultural heritage values within this corridor, and a subsequent meeting with DES was also held on 20 February 2019, to agree on the process required in the case that cultural heritage values would be required to be impacted within the proposed corridor. A desktop assessment of riparian vegetation has also been conducted which is provided in Section 5.13.2 of the IAR.

As stated in Section 6.5.2 of the IAR "*Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area*."

Within the alignment corridor it is proposed that the exact location of the infrastructure will be further refined through micro sighting, where feasible during detailed design, to further mitigate impacts on environmental features.

Response 7

Section:

Section 4.2.2 Design Refinement and Assessment of Alternatives

Review Comment:

This has now been addressed in part as the new Design Option 5, proposes to increase the capacity of Wises Pit to minimise discharge volume during construction.

Recommendation:

The IAR should detail all options that were considered, including for example irrigation, additional containment within expanded pit, construction of an additional storage facility.

As discussed in Section 4.2.2.5 of the IAR, following discussion and consultation with DES during 2018, Genex reconsidered the Proposed Design in light of the requirement to discharge over 1.5 GL of water during the construction phase to facilitate construction of the tailrace outlet structure within Eldridge Pit. The following options were considered:

Irrigation to land

The ability of irrigation to land to remove surplus water during the wet season is very limited as soils are typically at or near saturation point and unable to absorb irrigation water. Whilst irrigation to land was considered during the development of the Proposed Design, especially during construction, it was considered unsuitable given the volumes able to be removed and given the land area available.

Evaporative blowers

Genex considered the use of evaporative blowers during the construction phase to remove some of the excess water required for the construction of the tailrace outlet. It was decided that this option was not feasible due to the excessive cost and the lack of confidence that the technology would be able to remove the required volumes within an appropriate timeframe.

Temporary raising of spillway

DNRME has confirmed to Genex that it is comfortable with the proposal of temporarily holding excess water in Wises Dam above the FSL of 551.0m AHD (with the final design incorporating a spillway at 551.5m AHD and the dam crest of 552.7m AHD). The dam design incorporates a hydraulic gate arrangement that can be raised and lowered to adjust the effective spillway level to allow this temporary additional storage capacity in the dam and this functionality would be used temporarily to raise the spillway level of Wises Dam to 552.0m AHD (from 551.5m AHD during operation) to temporarily store a further 1.0 GL of water during construction of the tailrace within Eldridge Pit. It is intended that this will only be undertaken for the period during which the tailrace portal is being constructed, comprising approximately 6 months.

Excavation to provide additional storage

Whilst a number of excavation options were considered, it was determined that the most suitable and effective option is the excavation of additional 1.3 million m^3 of waste rock and 200,000 m^3 of virgin rock material from within Wises Pit to create an additional 1.5GL of water storage below the proposed minimum operating level (MOL) of 546 m AHD.

Resulting optimised proposed design

The subsequent Optimised Proposed Design (combining the additional water storage created by excavation and temporarily raising the spillway level of Wises Dam) was developed to store excess construction water such that releases of excess water are predicted to be required only to cater for seasonal inflows during both the construction and operational phases of the Project. These discharges will be controlled, event-based releases of water from the Project under conditions that are not considered to cause unacceptable environmental harm to downstream EVs, and are deemed to present the best option for the periodic release of excess water from the Project.

Response 8

Section:

Section 4.2.2 Design Refinement and Assessment of Alternatives

Review Comment:

Unclear in this section whether a release during construction is required as the additional water storage volume is 2.5 GL which is greater than the predicted volume to be discharged during construction.

Recommendation:

Clarify construction release requirements in this section.

As stated in Table 5 of the IAR, development of the Optimised Proposed Design from the Proposed Design (Design Option 5, as detailed in Section 4.2.2.5 of the IAR) considered mitigating the requirement to discharge excess construction water, such that this volume has now been reduced to zero and water can thereby be managed in line with the operational phase.

During both operations and construction, the existing body of water contained in the pit is effectively continually recycled around a semi-closed loop consisting of power generation and pump back. In the absence of evaporative losses and wet season inflows, the volume would remain constant, however due to these seasonal flows, the volume increases during the wet season and decreases due to evaporation during the dry season. Rainwater falling within each dam’s catchment area will therefore continue to contribute additional seasonal excess water.

As such, releases of excess water are still required during the construction phase to manage these seasonal inflows. These discharges will be undertaken as a controlled, event-based release of water from the Project under conditions that are not anticipated to cause unacceptable environmental harm to downstream EV.

Response 9

Section:

Section 4.2.3 Design consistency with Management Hierarchy for Surface or Groundwater (EPP Water)

Review Comment:

Table 5-Step 2, Waste Prevention. The first paragraph of this column is misleading as it infers that the volume of water to be released has been reduced to zero. This is in fact not that case.

Recommendation:

Amend this section to refer to the volume of water requiring release during construction and operations.

The Optimised Proposed Design (Design Option 5, as detailed in Section 4.2.2.5 of the IAR) was developed to store excess construction water such that releases of excess water are only required to cater for seasonal inflows during both the construction and operational phases under a controlled, event-based release of water from the Project under conditions that will not cause unacceptable environmental harm to downstream EVs. This option is deemed to present the best option for the periodic release of excess water from the Project.

As such, actual volumes released during both project phases will be dependent on inflows created by rainfall and will vary each year. Predicted median/95th percentile annual release volumes and other relevant statistics are presented in Table 2 below.

Table 2 Summary of Median and 95th Percentile Release Statistics for Operational and Construction Phases

Parameter	Operational Phase[A]	Construction Phase[B]
Median annual release volume	294 ML	409 ML
95th percentile annual release volume	1,737 ML	1,636 ML
Median release event volume	68 ML	101 ML
95th percentile release event volume	537 ML	550 ML
Median number of release events	4.0/year	4.4/year
95th percentile number of release events	8.0/year	7.7/year
Median release duration	7.0/days per event	7.7/days per event
95th percentile release duration	19.5/days per event	19.4/days per event

[A] Refer to Section 6.3.1 of the IAR for further detail.

[B] Refer to Section 7.4.1 of the IAR for further detail.

2.3 Impact Assessment – Operational Releases

Response 10

Section:

Section 6.1.1.2 Dilution Ratio for Adoption

Review Comment:

This section describes the use of up to 69% of the receiving environment's assimilative capacity during operational releases. It is expected that during the wet season some assimilative capacity may already be taken up by overtopping of the Kidston tailing dams and other inputs of runoff from the Kidston site. The assimilative capacity of the receiving environment used by the current development, excluding the proposed water releases, should be described in full in this section. The cumulative impact of all inputs (including the proposed construction and operational releases) from the project into the Copperfield River must also be more concisely discussed.

Recommendation:

This section should include a comprehensive analysis of the assimilative capacity of the receiving environment already used by the current Kidston Development, including stormwater runoff and tailing dams overtopping during the wet season. It should also include a more detailed quantitative analysis of the potential cumulative impacts of all inputs from the site into the Copperfield River (including the proposed construction and operational releases).

The assessment of assimilative capacity usage and surface water quality impacts associated with releases are based on historical data from the Copperfield River at monitoring location W2. As stated in the IAR, *"…examination of baseline receiving environment data (Sections 4.9.3. and 5.6) for monitoring point W2 indicates a localised elevation of key contaminant concentrations which are likely to be as a result of release of seepage water from point sources in the SIS [Seepage Interception System] as well and more diffuse subsurface sources entering the Copperfield River at or near to W2*." The resultant estimation of available assimilative capacity in the receiving environment therefore includes partial inclusion of the existing contaminant load leaving the Project site.

As reported in previous versions of the IAR comments register, there is insufficient data to support the type of assessment requested. There is no data pertaining to either water quality or quantity of discharge from other sources. A qualitative discussion was provided in Section 4.3.1 of the IAR and includes reference to ongoing and proposed monitoring that will be used to develop a greater understanding of these inputs.

Furthermore, the use of 69% of the receiving environment's assimilative capacity during the operational phase and 76.3% during the construction phase is based upon the maximum concentration of dissolved zinc in the release water and therefore represents a worst-case scenario unlikely to eventuate in reality. Assimilative capacity usage associated with other (higher probability) release concentrations is presented in Table 1.

Response 11

Section:

Section 6.2.1 Near Field Mixing Zone Assessment (CORMIX)

Review Comment:

There is a potential risk of algal blooms within the mixing zone. With the concentration of total nitrogen in the release water 43 times, nitrate 7 times and total phosphorus 3 times the WQO.

The nutrient load to the system will also be increased due to the release.

Recommendation:

Assess the potential for algal blooms within near field mixing zone.

A detailed assessment of nutrient concentrations and risk of algal bloom associated with Project releases is presented in Appendix B of this Supplementary information.

As presented in Section 6.2.1 of the IAR, worst case CORMIX modelling results for the operations phase indicates a maximum distance of 623 m downstream before the WQO (HMTV) for dissolved zinc is met (and therefore releases are adequately mixed with receiving environment water). CORMIX modelling has now also been undertaken for construction phase releases (refer to Response 19 for further detail) and indicates a maximum mixing distance of 772 m downstream of the release location.

The likelihood of algal blooms associated with Project releases is considered to be low, for the reasons outlined in Appendix B of this Supplementary information. With specific reference to the near field mixing zone, the risk is considered low for the following reasons:

- Releases will only occur during periods of high flow, which are generally not conducive to algal blooms; lakes, ponds and slow-moving rivers being more susceptible to algal blooms. No permanent or semi-permanent pools (which could be more susceptible to blooms once flow in the river has ceased) have been identified within the maximum modelled mixing zone area of 772 m downstream of the release. The first identified pool (Pond 4) is located approximately 5.4 km downstream of the release location.
- Risk of algal blooms in not only the mixing zone, but also downstream pools/waterholes and the Einasleigh Gorge is minimised by ensuring that post-release flushing of extended duration (median post-release flush duration of between 29 and 32 days) and volume (median post-release flush volume of between 1,676 and 1,758 ML) occurs following each release event.
- Analysis of post release flushes shows that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase. Due to tributary inflows downstream of the release, post release flushes at Einasleigh (located approximately 48 km downstream of the release point) are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.
- Releases are infrequent (median of between 4.0 and 4.4 events per year) and temporary in nature, with an anticipated median duration of between 7.0 and 7.7 days per event.

In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

Response 12

Section:

Section 6.2.2.5 Scenario 3 – Annual Mass Balance Simulation for Comparative Assessment of Nine Constituents of Most Concern

Review Comment:

The conclusion in the Section 6.2.2.5 does not appear to be entirely correct. The concentration of dissolved zinc under the worst case scenario is greater than the WQO at all locations, including the release point and East Gilbert Creek in Table 65.

Recommendation:

-

The review comment provided is incorrect. The concentration of dissolved zinc under the worst case scenario does not exceed the hardness-modified trigger value (HMTV) at the release point or East Creek during either the operational phase or construction phase (refer to Table 3 below).

Prior to finalising the IAR, it was agreed with DES that it is appropriate to apply the HMTV (rather than the default WQO) within this zone. As stated in Section 5.6.1 "*The median hardness in the receiving environment at W2 is 56 mg/L, therefore the procedure outlined in Section 3.4.4 of the ANZECC/ARMCANZ 2000 ('Applying guideline trigger values to sites'), was applied, using a hardness value of 56 mg/L. This is considered to be a conservative estimate of the trigger value, as once mixed with the release water (median hardness of 1374 mg/L) the hardness will be higher than 56 mg/L, thereby resulting in a higher HMTV.*"

Table 3 Dissolved Zinc Concentrations Predicted by Mass Balance Modelling at Release Point and East Creek

Location	Mass Balance Statistic	HMTV for Dissolved Zinc (mg/L)*	Operations Phase Dissolved Zinc Release Conc. (mg/L)		Temporary Construction Releases Dissolved Zinc Release Conc. (mg/L)	
			Median	Maximum	Median	Maximum
Proposed Release Point (0 km)	Mean	0.014	0.006	0.010	0.0059	0.011
	Median	0.014	0.006	0.010	0.0059	0.011
	P95	0.014	0.006	0.010	0.0059	0.011
East Creek (Gilberton Road) (6.9 km)	Mean	0.014	0.005	0.009	0.0053	0.010
	Median	0.014	0.005	0.009	0.0053	0.010
	P95	0.014	0.005	0.010	0.0055	0.010

*Based on default WQO for 95% species protection

Source: AECOM 2019, Table 65 and Table 92

Response 13

Section:

Section 6.2.3 Assessment of Water Quality Impacts to Environmental Values

Review Comment:

The concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream.

The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus.

However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular in semi-permanent pools downstream.

Recommendation:

Include release of Total P from the pits as a source of phosphorus.

As shown in Table 55 and Table 85 of the IAR, the concentration of total phosphorus in the receiving environment post release is well below the WQO (final receiving environment concentration of 0.0052 mg/L compared with the WQO of 0.01 mg/L).

A detailed assessment of nutrient concentrations (including total phosphorus in the pits) and risk of algal bloom associated with Project releases is presented in Appendix B of this Supplementary information. In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release point and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

As discussed as part of Response 20, analysis of post release flushes shows that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase. Due to tributary inflows downstream of the release, post release flushes at Einasleigh (located approximately 48 km downstream of the release point) are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.

Response 14

Section:

Section 6.2.3 Assessment of Water Quality Impacts to Environmental Values

Review Comment:

The impact assessment makes mention of photographic monitoring of the release point to monitor erosion or deposition, but does not mention potential mitigation measures to avoid or minimise erosion of deposition.

Recommendation:

Include mitigation measures to assist in the avoidance and minimisation of erosion or deposition at the release point.

A discussion regarding the risk of erosion/deposition (including design mitigation measures) is presented in Section 6.5.2 (Fluvial Geomorphology) of the IAR:

"*Design and construction of the proposed outlet structure will need to make appropriate consideration of the potential for enhanced erosion and scour as a direct result of potential discharge outlet velocities as well as a result of any associated in-stream structures. In order to ensure that erosion and scouring impacts are not occurring a result of operational releases, regular (quarterly) visual inspections of the outlet structure and surrounds are proposed (refer to Section 9.2 for further detail).*

It is proposed to confirm the location of the actual release point as the Project progresses through detailed design. Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area."

Response 15

Section:

Section 6.2.1.5 Scenario Results

Review Comment:

This section mentions "other modelled scenarios". Verify that this modelling is also included in the IAR. If it is not currently included, it should be.

Recommendation:

Confirm "other modelled scenarios" are included in the IAR. If not, amend the IAR to include these other scenarios.

This should be considered in the context of the surrounding text. The text in question refers to CORMIX modelling Scenario 2, which indicates that the maximum mixing distance is 623 m downstream of the release point. The "*other modelled scenarios*" referred to in this section of the IAR are CORMIX modelling Scenarios 1, 3 and 4 (as summarised in Section 6.2.1.4 of the IAR). These other modelled scenarios indicate a much smaller mixing zone (between approximately 52 and 67 m downstream).

Response 16

Section:

Section 6.2.4 Conclusion of Water Quality Impact Assessment

Review Comment:

Potential entrainment and contamination of sediments in the mixing zone has not been addressed.

Recommendation:

Include potential for sediment contamination in risk assessment.

Sediment investigation will be undertaken as part of the REMP to characterise and compare upstream/downstream sediment quality. The outcome of this investigation will detail actions/mitigation strategies should unacceptable impacts be determined.

The concentrations of metals in the release water, although exceeding WQOs, are not very high compared to other industries and mining activities. Therefore the risk of contaminating sediments is considered relatively low compared to other release regimes (such as mine water releases). A commonly applied release regime in mining Environmental Authorities is to set Stock Water Drinking limits as the release limits and aquatic ecosystem values as the receiving environment trigger values. This kind of regime will allow water to be released from a mining activity at concentrations up to the Stock Water Drinking Limits, so long as there is enough flow in the receiving environment to ensure that trigger values are met at downstream receiving environment monitoring locations. The Stock Water Release Limit is 20mg/L for zinc. The maximum concentration of zinc proposed to be released from this Project is approximately 2.35mg/L (as total zinc).

Sediment contamination under the Project is far less likely to occur compared to the release limits that can be applied to typical mining activities in the State as the concentrations of parameters proposing to be released are far less. The monitoring framework outlined in the REMP will monitor any changes in metals concentrations of sediments at upstream sites and proposes a framework that involves comparison of downstream sites to upstream sites, as well as Sediment Quality Guidelines. The REMP Assessment Report, to be completed each year by a suitably qualified person, should assess the sediment data in context of the initial sediment investigation (also proposed in the REMP), upstream and downstream data as well as Sediment Quality Guidelines. Evaluation of yearly sediment data based on this framework is considered appropriate to monitor sediment quality changes, and if necessary mitigation measures.

2.4 Impact Assessment – Temporary Construction Releases

Response 17

Section:

Section 7.2 Preliminary Construction Phase Assessment

Review Comment:

It is unclear in Section 7 what the required discharge volume during construction will be based on the new design option 5.

Section 7 only states that there will be a significant reduction in the excess construction water volume.

The additional water storage volume under option 5 of 2.5 GL is greater than the previous predicted volume to be discharged during construction of 1.5 GL. It is therefore, unclear why discharge is still required during construction.

No justification has been given to why the same conditions that are proposed for the operational phase have been applied to construction.

Of note is that the concentration of dissolved zinc, nitrate and total nitrogen is greater in Eldridge Pit than the mix of water to the discharged during operation (9 parts Eldridge to 1 part Wises Pit).

Recommendation:

Further detail is required in the last paragraph in Section 7.2.1.2 on page 235 regarding the proposed volume of water to be discharged during construction and the proposed construction conditions.

As stated in Response 8, development of the Optimised Proposed Design from the Proposed Design (Design Option 5, as detailed in Section 4.2.2.5 of the IAR) considered mitigating the requirement to discharge excess construction water, such that this volume has now been reduced to zero and water can be managed in line with the operational phase.

During both operations and construction, the existing body of water contained in the pit is effectively continually recycled around a semi-closed loop consisting of power generation and pump back. In the absence of evaporative losses and wet season inflows, the volume would remain constant, however due to these seasonal flows, the volume increases during the wet season and decreases due to evaporation during the dry season. Rainwater falling within each pit's catchment area will therefore continue to contribute additional seasonal excess water.

The subsequent Optimised Proposed Design was developed to store excess construction water such that releases of excess water are only required to cater for seasonal inflows during both the construction and operational phases under a controlled, event-based release of water from the Project under conditions that will not cause unacceptable environmental harm to downstream EVs. This option is deemed to present the best option for the periodic release of excess water from the Project. As such, actual volumes released during both project phases will be dependent on inflows created by rainfall and will vary each year. Predicted median annual release volumes and other relevant statistics are presented in Table 2 above (Response 9).

It should also be noted that the volume of water within the pits, and hence the excess construction water required to be discharged, is variable from season to season but on a long term average basis remains constant (i.e. excessive wet seasons would result in a higher volume, dry wet seasons would result in a lower volume).

Response 18

Section:

Section 7.2.1.2 Construction Stages and Model Objective Functions

Review Comment:

It remains unclear in this section what is maximum volume of release required during the construction phase, and the source (Eldridge/Wises/Mix) of any proposed release releases at different times during the construction period.

Recommendation:

The maximum volume (worst case scenario) which may be required to be released during construction should be providing, including the source (Eldridge/Wises/Mix) of any proposed release releases at different times during the construction period.

As stated in Table 2 of the IAR, releases during the construction phase will initially be sourced from the Eldridge Pit only. This will continue until the final stage of dewatering of the Eldridge Pit has been completed and construction of the tailrace works has commenced. For the remainder of the construction phase releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises.

As stated as part of Response 9, actual volumes released during both phases of the Project will be dependent on inflows created by rainfall and will vary each year; maximum release volumes therefore cannot be determined. Predicted median/95th percentile annual release volumes and other relevant statistics for both the operation and construction phases are presented in Table 2 above.

Response 19

Section:

Section 7.3.1 Near Field Mixing Zone Assessment

Review Comment:

No new near field mixing zone modelling has been done for the proposed construction phase release.

The reason provided for this is that the same release conditions as the operational phase will be used. However, as outlined above, the concentration of dissolved zinc, nitrate and total nitrogen is greater in Eldridge Pit than the mix of water to the discharged during operation (9 parts Eldridge to 1 part Wises Pit). Therefore, the worst case scenario has not been modelled for these parameters.

It is also suggested that the outfall structure may not be complete and that initial releases during the construction phase may be via a simple outfall structure. Mixing zone modelling for operation included two different conceptual diffuser configurations. Therefore, as per previous comments, the modelling for the operational phase does not provide the worst case scenario of a simple/temporary outfall structure. Mixing zone impacts of entrained metals in sediments should also be addressed.

Recommendation:

Provide mixing zone modelling representing the construction release conditions (source water, maximum release volume, outfall structure).

CORMIX modelling has now been undertaken for the construction phase. Modelling was undertaken for the same four scenarios assessed for the operational phase of the Project (refer to Section 6.2.1.4 of the IAR for detail), however assumes a higher dissolved zinc concentration in release waters than for the operations phase. The operations phase assumed a maximum dissolved zinc concentration in release water of 1.59 mg/L which is the maximum resulting from the 9:1 mix of Eldridge Pit to Wises Pit. The construction phase assumes a maximum dissolved zinc concentration in release water of 1.75 mg/L which is the maximum concentration observed in Eldridge Pit (the most likely source of release water during construction).

The estimated mixing zone length for temporary construction releases is summarised in Table 4 along with Figure 2 to Figure 5. From the results it can be seen that the proposed releases are subject to initial mixing within the near field and that predicted water quality within the mixing zone reaches the WQO for dissolved zinc, being the contaminant of most concern, within a **maximum** distance of 772 m. Three out of the four modelled scenarios indicate a much smaller mixing zone of between 62 and 86 m downstream, therefore it is predicted that the mixing zone in most cases will be 86 m or less.

It can now be confirmed that no releases will be undertaken without a diffuser and that appropriate infrastructure will be in place prior to construction phase releases occurring.

Table 4 Construction Phase Scenario Results for Estimated Mixing Zones

Scenario	Estimated Mixing Zone Length (m)	Estimated Scenario Channel Width (m)
1	62.1	31.8
2	771.7	82.8
3	86.3	124.5
4	73.7	134

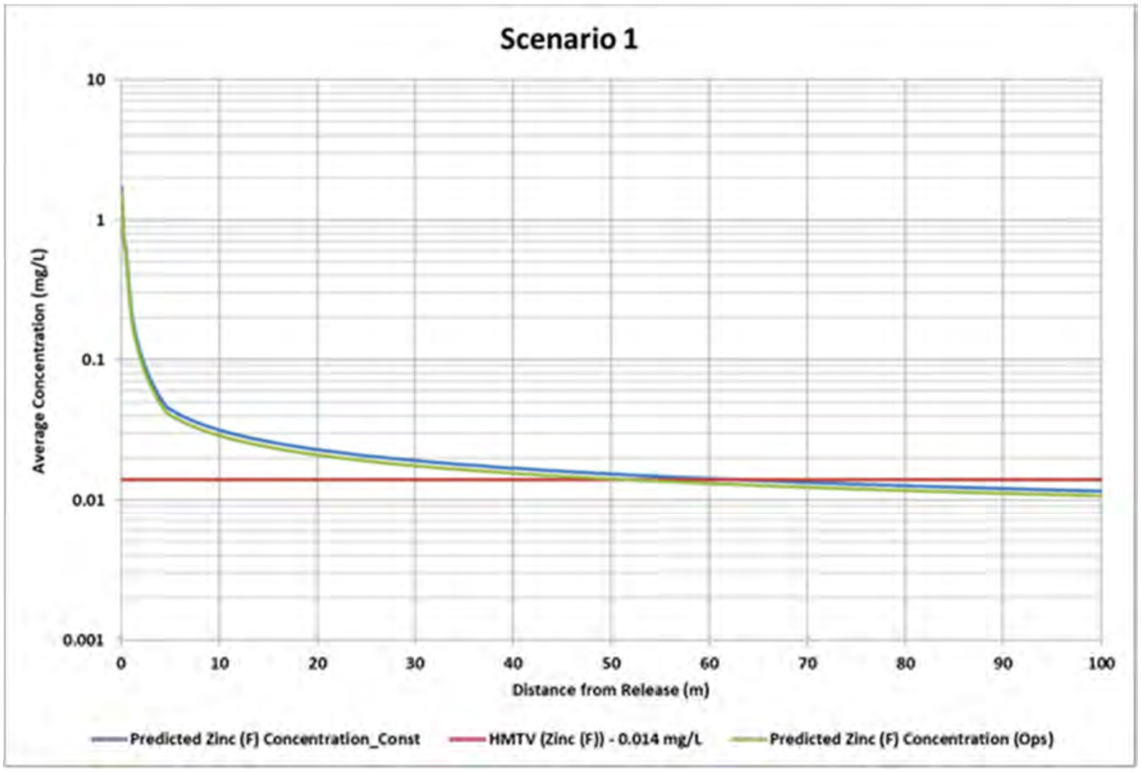


Figure 2 Construction phase mixing zone dissolved zinc concentrations as predicted by CORMIX – Scenario 1

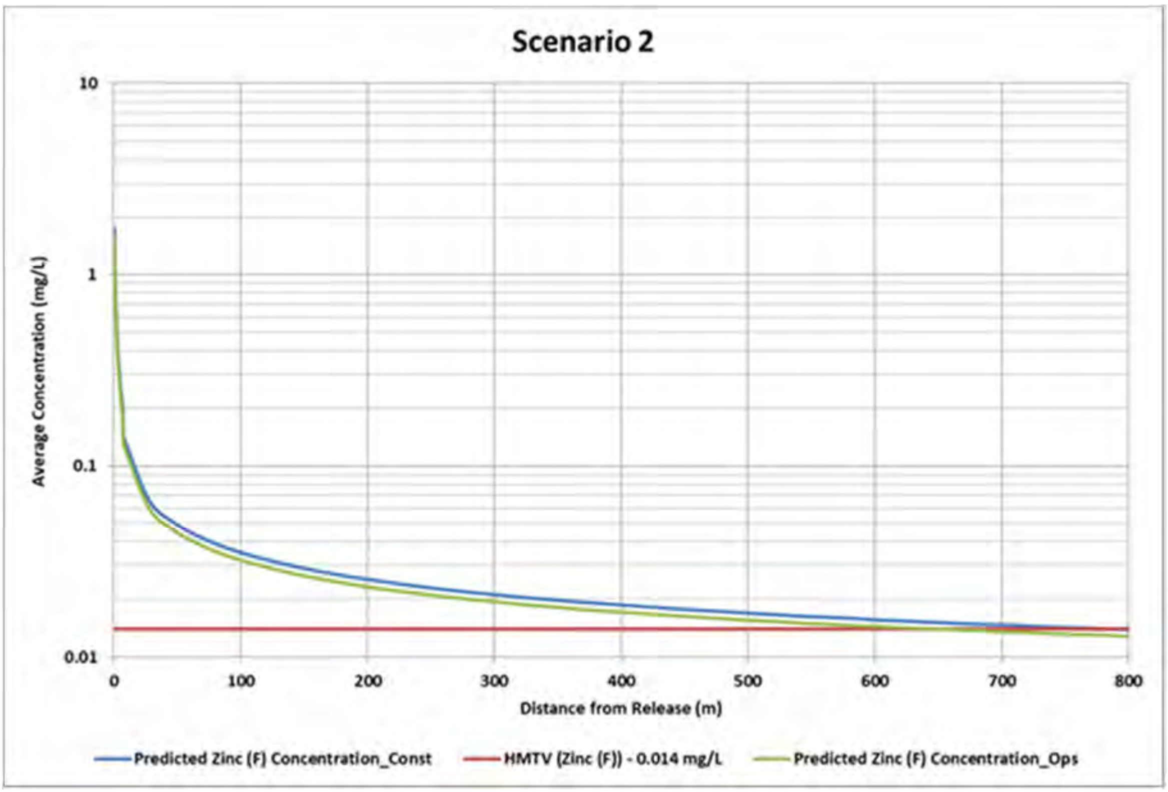


Figure 3 Construction phase mixing zone dissolved zinc concentrations as predicted by CORMIX – Scenario 2

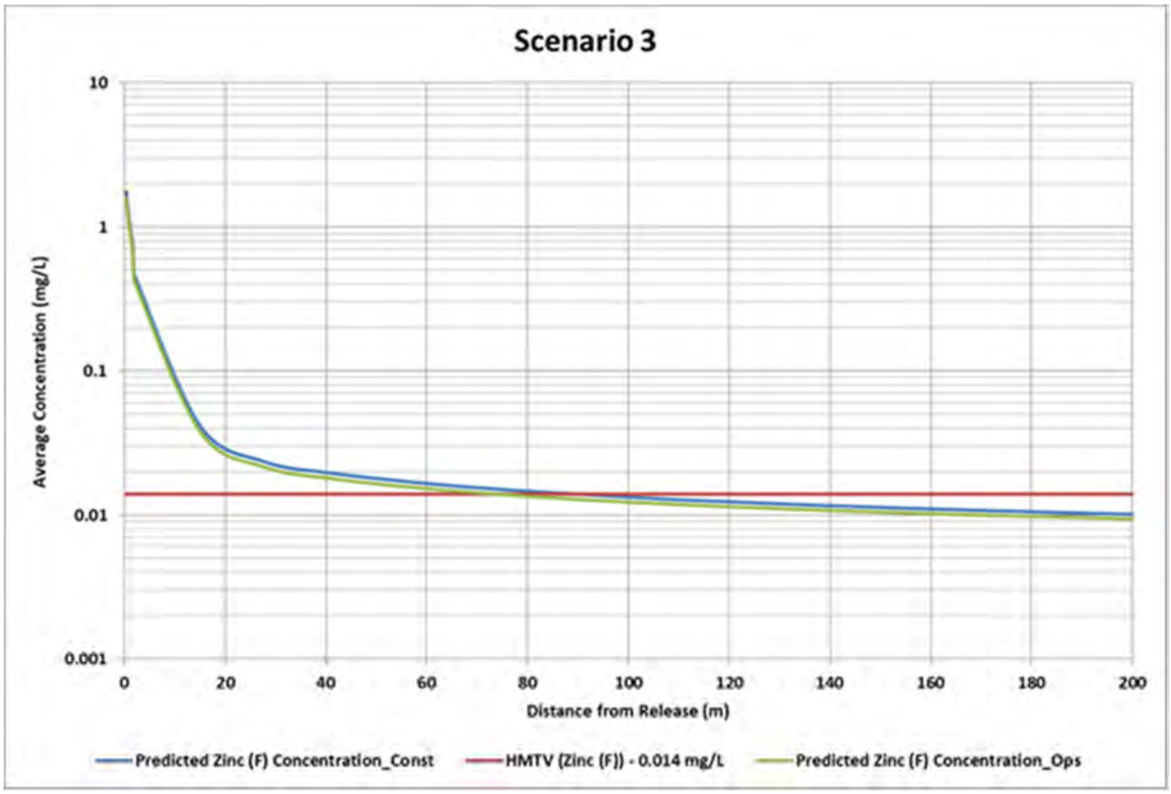


Figure 4 Construction phase mixing zone dissolved zinc concentrations as predicted by CORMIX – Scenario 3

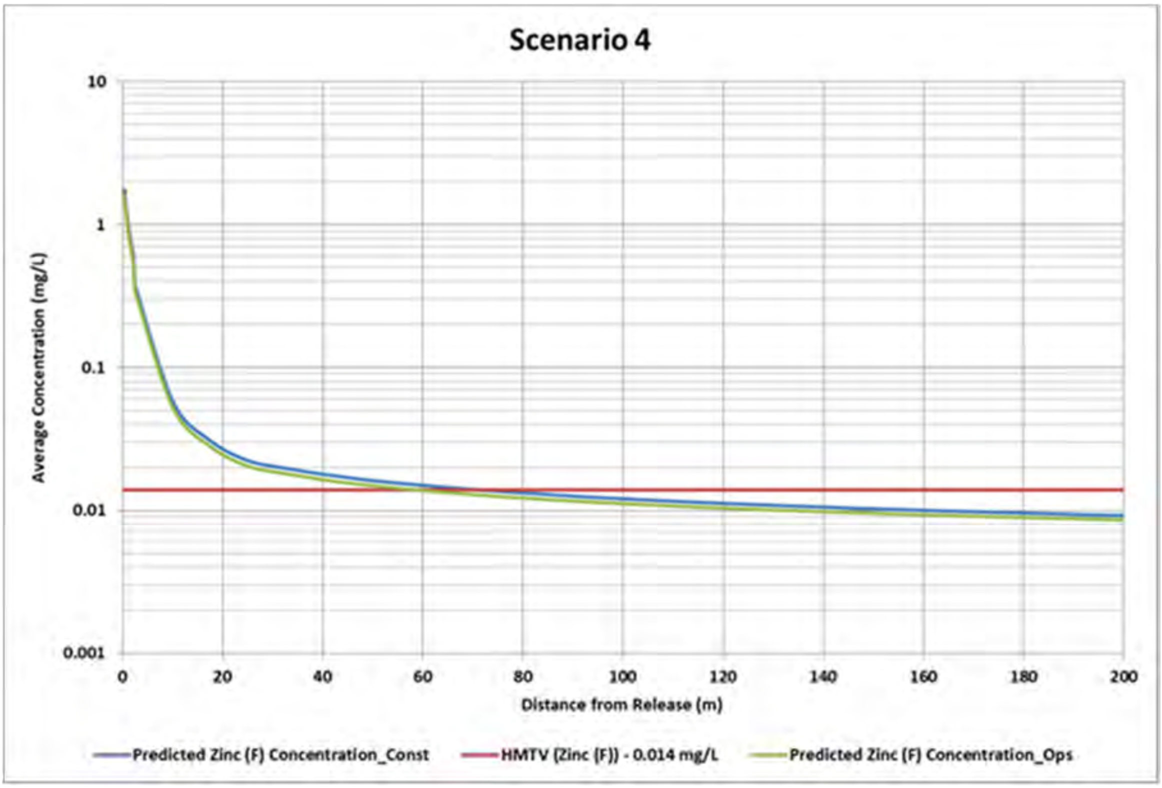


Figure 5 Construction phase mixing zone dissolved zinc concentrations as predicted by CORMIX – Scenario 4

Response 20

Section:

Section 7.3.2 Far Field Assessment of Sustainable Load (Mass Balance)

Review Comment:

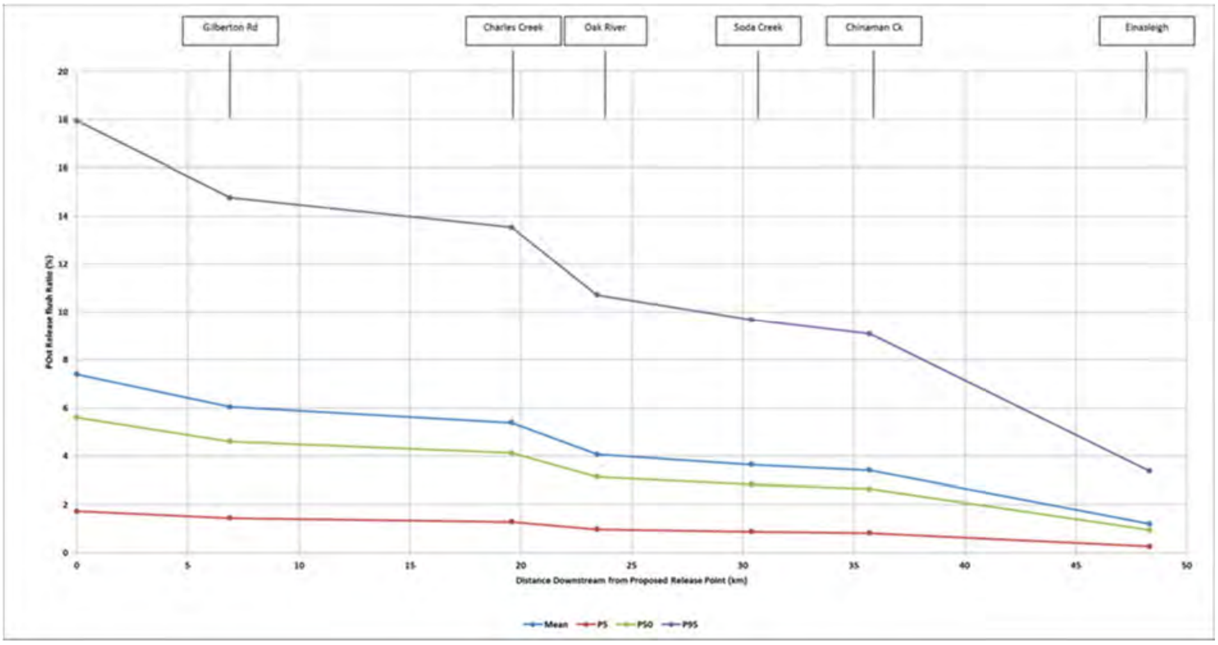
There is a potential risk of algal blooms within the mixing zone and the semi-permanent pools downstream. With the concentration of total nitrogen in the release water 47 times, nitrate 8 times and total phosphorus 2.5 times the WQO. Efficacy of proposed flushing (i.e. cease release at <400ML/d) in downstream water bodies (i.e. Copperfield Gorge) is inadequately discussed.

Recommendation:

-

Detail regarding post-release flushes is presented in Section 6.3.1 (for operational phase releases) and Section 7.4.2 (for temporary construction releases) of the IAR. The efficacy of flushing with regards to the potential for algal blooms is discussed in Appendix B of this Supplementary information.

Analysis of post release flushes show that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase (refer to Table 69 and Table 102 of the IAR). As shown in Figure 6, tributary inflows downstream of the proposed release point provide continual additional flow during the post-release flush period resulting in a continual reduction in the flush ratio[1] with increasing distance downstream of the proposed release point. At Einasleigh (located approximately 48 km downstream of the release point), post release flushes are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.



Source: AECOM, 2019, Figure 72

Figure 6 Construction Phase Post-Release Flush Ratios – Annual Results

Response 21

Section:

Section 7.3.4 Assessment of Water Quality Impacts to Environmental Values

Review Comment:

The concentrations represented by the mass balance will only be present whilst the release is occurring. However, the section does not provide examples of how long the system takes to returns to < WQOs, how long the water takes to move from Kidston to Einasleigh, etc.

Recommendation:

The IAR needs to detail, how long the system takes to returns to < WQOs in scenarios where they are being exceeded for large periods downstream, how long the water takes to move from Kidston to Einasleigh (i.e. days/weeks), how long will elevated concentrations be present at that location; and the proportion of days per year where there is ‘unimpacted’ water present in the system, compared to release impacted days.

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[1] Post-release flush ratios are calculated by dividing the mean event release volume by the mean post-release flush volume. A lower value indicates a higher flush volume in relation to the release volume.

An assessment of the system response timing was undertaken using the GoldSim water and mass balance model developed for the Project. It is important to note the following with regards to the assessment:

- Any assessment of model results is founded on simplified representations of the system based on the available information and is therefore approximate only. The approach taken throughout the IAR has been to assess the most conservative cases (e.g., highest water quality concentrations, most conservative assimilative capacity and does not take into account factors that may cause natural attenuation of contaminants etc.) and these assumptions have been carried through across all modelling presented here.
- The response timing assessment should be considered as providing the relative variations in the system in response to Project releases, rather than absolute values.

The system response assessment was conceptually designed around the releases of Project water to the Copperfield River, during the construction and operational phases of the Project. This follows the design of Project releases in that these only occur if necessary to maintain Project volumes and prevent overtopping, and only if the flow of the Copperfield River is above a threshold (>400 mL/day). Parameters used in this assessment are shown in Table 5 and focus on dissolved zinc, the chief contaminant of potential concern (i.e. requiring the highest level of dilution to achieve water quality objectives). All values are from the IAR.

Table 5 Parameters used in the system response assessment

Parameter	Value
Dissolved zinc HMTV (95% species protection)	0.014 mg/L
Dissolved zinc default WQO (95% species protection)	0.008 mg/L
Baseline dissolved zinc concentration (W2)	0.0025 mg/L
Worst case final concentration in the receiving environment for construction phase releases	0.0113 mg/L*
Worst case final concentration in the receiving environment for operational phase releases	0.0104 mg/L**
Estimated construction phase duration	2.15 years

*Based on an EOP release concentration of 1.75 mg/L (maximum for Eldridge Pit)

**Based on an EOP release concentration of 1.59 mg/L (maximum value for 9:1 composite mix)

The assessment uses the Copperfield River flow record (ML/day) and the simulated construction and operational release rates (ML/day) to calculate the dissolved zinc load added to the Copperfield River (kg/day) during modelled release events and expressed as a change in concentration (mg/L). A conservative system assimilative capacity of 25 % (i.e., more conservative than the lowest assimilative capacity shown in Table 1) was used to assume the worst-case impacts to the receiving system. Figure 7 shows the simulated zinc concentrations resulting from the releases during the construction and operations phases under the conservative conditions. As Figure 7 illustrates, dissolved zinc is simulated as a conservative species (i.e., no natural attenuation) and modelled concentrations are entirely dependent on the zinc load added to the Copperfield River following release.

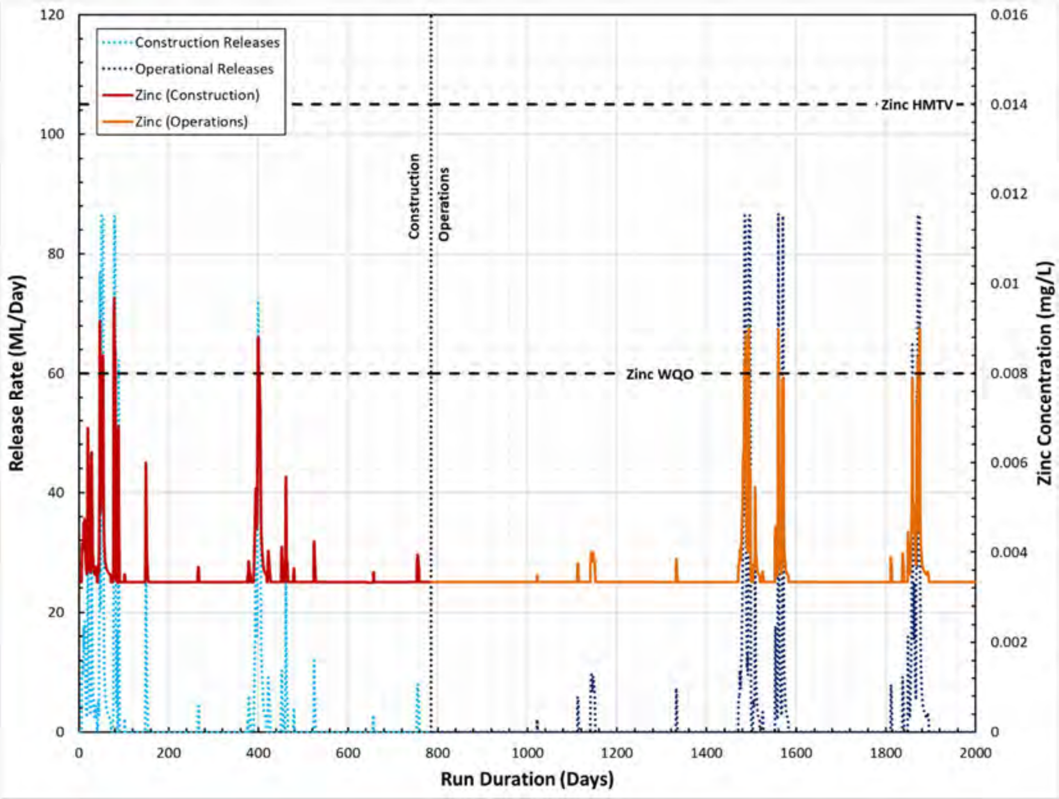

Figure 7 Comparison of the simulated release rates during the construction and operations phases of the Project (left-hand scale) with zinc concentrations (right-hand scale), assuming 'worst-case' conditions throughout the model

Note: Also shown for comparison are the zinc HMTV (applied to the receiving environment in the vicinity of the release) and zinc WQO (downstream water quality objective). Note that the simulation duration was ~ 130 years but the first 5 years only are shown for clarity to illustrate the variation in water quality from the construction phase to the operations phase

The results have been used to address the following DES queries on the IAR:

- *How long [does] the system takes to return to < WQOs in scenarios where they are being exceeded for large periods downstream:*

  Figure 8 details simulated releases within the first 100 days of the construction period. Note that the simulations predict zero exceedances of the HMTV for zinc. Downstream zinc WQOs are predicted to be exceeded briefly. Since the load added to the Copperfield River is depended on the release flow, once a release period ends, concentrations are calculated to return to below the WQO within approximately two days and to return to baseline Copperfield River concentrations (0.0025 mg/L) within approximately ten days, which is consistent with the post-release flushing estimated in the IAR.

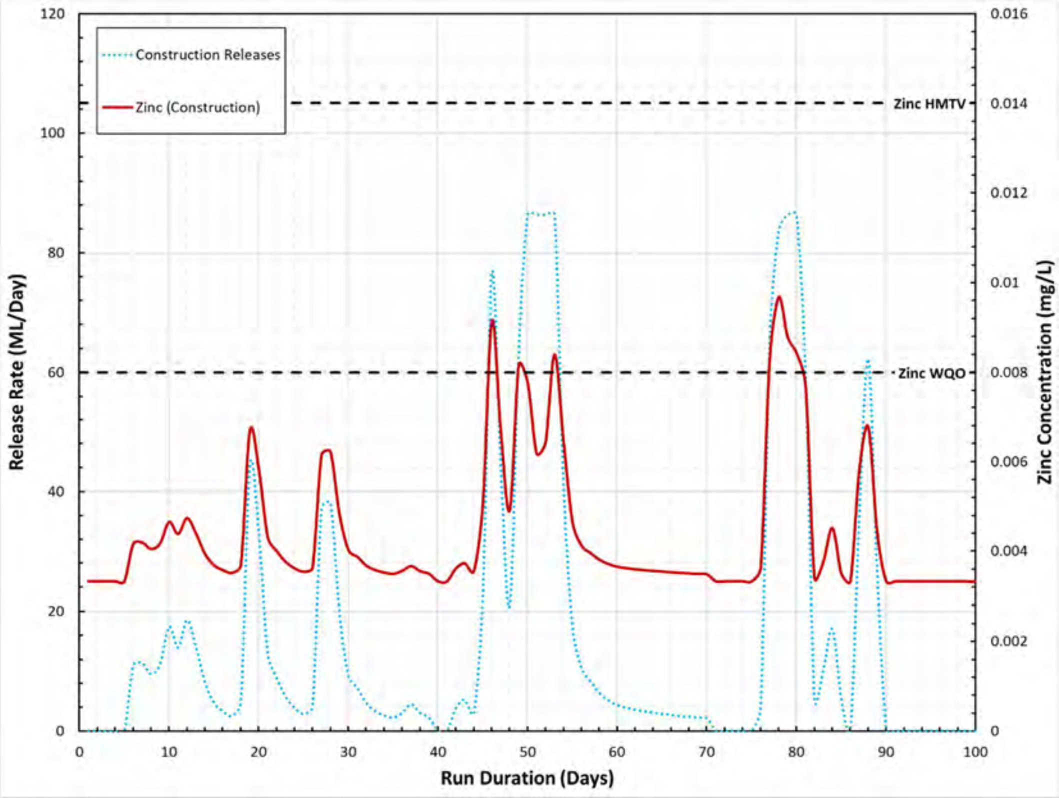

Figure 8 Simulated release flows and zinc concentrations during the first 100 days of the construction phase

- *How long the water takes to move from Kidston to Einasleigh (i.e., days/weeks):*

  The hydraulic model presented in Section 5.10.1.2 of the IAR presents a hydraulic model of the Copperfield River approximately 7.5km upstream and 4.5km downstream from the proposed release location. The average stream velocity throughout this reach is approximately 0.52m/s. At this velocity it will take approximately 23 hours for water to reach Einasleigh (44km downstream).

- *How long [will] the elevated concentrations be present at that location:*

  As above, this is dependent on the load added to the Copperfield River, which is dependent on the release flow rate and the maximum is simulated to be in the order of approximately ten days (Figure 8).

- *The proportion of days per year where there is 'unimpacted' water present in the system, compared to release impacted days:*

  The number of days exceeding the zinc WQO[2] is predicted to be approximately 0.5 % of the approximately 130 year simulation, which results in approximately 363 days per year (364 days in a leap year) unimpacted. Perhaps a better indication is provided by estimating the number of days per year that exceed the baseline concentration, which is predicted to be approximately 60 (approximately 15 %).

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[2] NOTE: This calculation is based on the conservative WQO rather than the HMTV.

Response 22

Section:

Section 7.3.4 Assessment of Water Quality Impact to Environmental Values

Review Comment:

This section has been updated based on the design option 5.

As outlined above (Section 6.2.3), the concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream.

The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus.

However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular semi-permanent pools downstream.

Recommendation:

-

A detailed assessment of nutrient concentrations and risk of algal bloom associated with Project releases is presented in Appendix B of this Supplementary information. In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

As discussed as part of Response 20, analysis of post release flushes shows that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase. Due to tributary inflows downstream of the release, post release flushes at Einasleigh (located approximately 48 km downstream of the release point) are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.

Response 23

Section:

Section 7.3.4 Assessment of Water Quality Impact to Environmental Values

Review Comment:

This section has been updated based on the design option 5.

As outlined above (Section 6.2.3), the concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream.

The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus.

However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular semi-permanent pools downstream.

Recommendation:

A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided.

A detailed assessment of nutrient concentrations and risk of algal bloom associated with Project releases is presented in Appendix B of this Supplementary information. In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

As discussed as part of Response 20, analysis of post release flushes shows that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase. Due to tributary inflows downstream of the release, post release flushes at Einasleigh (located approximately 48 km downstream of the release point) are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.

Response 24

Section:

Section 7.3.5 Conclusion of Water Quality Impact Assessment

Review Comment:

This section has been updated based on the design option 5. Therefore, most comments are no longer valid. However, the comment regarding a detailed assessment of the potential for algal blooms is still required. This is relevant for operation and construction releases. A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided. The proponents mention that there is no evidence of algae growth within Eldridge Pit to date, despite nitrate levels of 5 mg/L. The toxicity assessment revealed that 100% Eldridge water was non-toxic within an algae test, i.e. it did not inhibit growth. Hence an assessment is required regarding other important factors downstream including turbidity and settling which may inhibit or promote algal growth

Recommendation:

A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided. The proponents mention that there is no evidence of algae growth within Eldridge Pit to date, despite nitrate levels of 5 mg/L. The toxicity assessment revealed that 100% Eldridge water was non-toxic within an algae test, i.e. it did not inhibit growth. Hence an assessment is required regarding other important factors downstream including turbidity and settling which may inhibit or promote algal growth.

A detailed assessment of nutrient concentrations and risk of algal bloom associated with Project releases is presented in Appendix B of this Supplementary information. In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

As discussed as part of Response 20, analysis of post release flushes shows that for 95% of releases, the post release flush at the proposed release point is estimated to exceed seven times the release volume during the operational phase and more than five times the release volume during the construction phase. Due to tributary inflows downstream of the release, post release flushes at Einasleigh (located approximately 48 km downstream of the release point) are estimated to exceed the release volume by approximately 42 times during operations and 29 times during construction for 95% of releases.

Response 25

Section:

Section 7.3.5 Conclusion of Water Quality Impact Assessment

Review Comment:

The assumption that the river will not be used for recreation in high flow conditions is not an acceptable measure to avoid the impacts of the exceedance of recreation WQO for Manganese.

Recommendation:

Explore and fully describe suitable additional mitigation measures to further limit the exceedance of WQO.

The revised assessment for temporary construction releases presented in the final IAR (along with the original operational phase assessment) indicates that there will be no exceedances of the WQO for manganese or any other WQO designed to protect recreational EVs in the receiving environment. This comment is therefore no longer considered applicable.

2.5 Release Criteria and Monitoring

Response 26

Section:

Section 9.1 Summary of Proposed Release Criteria

Review Comment:

Release conditions should include contaminant end of pipe triggers and limits for the relevant parameters, in addition to conditions regarding flow triggers and minimum dilutions. The impact assessment has been undertaken on the basis of assessing the risk of 1:25 or 1:200 assuming water quality from historical information (and based on the site water balance predictions of what will be required in terms of discharges). Licensing processes utilise information from the impact assessment to then consider the appropriate conditions, EOP and within the receiving environment. Assumptions cannot be reliably made to assert that water quality within the pit will not alter (or deteriorate) over the operation lifetime. This is especially important, given the likely increased ingress of groundwater once the current water levels in Eldridge Pit are dropped. There is also an identified potential for oxidisation of the sulphides and liberation of cadmium, zinc, copper and arsenic from pit walls.

The previous comments are still valid, except those related to the 1:25 dilution for construction.

Recommendation:

If the maximum release rate is proposed to be adjusted on real time data from upstream gauge, then the minimum flow triggers should also be managed on a real time or short term basis (i.e. cubic metres/second, rather than ML/Day). Any request to use variable release ratios (volumes) based on real time dilution factor with the receiving water flows presents additional complications in regards to the onsite management and compliance assessment. A discussion of how the onsite management would be designed to enable rapid alterations of discharge volumes to fluctuating natural stream flows should be detailed within the IAR.

Some early attempts to develop an EOP limits appear to have been presented for dissolved zinc for operational discharges, but nothing has been presented for the construction phase limits. If modelling has assessed EOP maximum of 1.58-1.75 for dissolved zinc then this will more closely reflect the EOP limit, which should then be applied. Doubling the end of pipe limit would require impact assessments and modelling using the requested limit, and this has not been undertaken.

The release ratio during the construction phase of 4.2% listed in Table 108 does not equate to 25:1. The release ratio should read 4%. This error needs to be corrected throughout the documents.

The impact assessment undertaken as part of the IAR is based on maximum observed concentrations of key contaminants in either of the following sources of releases:

- Eldridge Pit – this applies to the initial phases of the construction period until the final stage of dewatering of the Eldridge Pit has been completed and construction of the tailrace works has commenced.
- Mixture of 9 parts Eldridge Pit to 1 part Wises Pit - this applies to all operational phase releases and releases undertaken during the latter part of the construction phase.

A summary of maximum observed values is presented in Table 6 below. It should be noted that these values are based on a limited dataset size for some parameters (less than 10 samples for all metals and nutrients).

As stated in Section 9.1 of the IAR, the proposed release ratio (i.e. the ratio of the release flow to the receiving flow) is dependent on assumptions regarding:

- Concentration of the contaminant of most concern in the potential release water;
- Concentration of the contaminant of most concern in the receiving environment; and
- Adopted utilisation of the available assimilative capacity for the contaminant of most concern.

However, real time monitoring in the receiving environment and the Eldridge and Wises Pits for some key contaminants such as metalloids is not practical. Potential changes to the concentration of contaminants in either the release water or the receiving environment can influence the effective assimilative capacity utilisation. The proposed release ratio of 0.5% for the operational phase of the Project has been based on:

- A conservatively high release concentration of 1.5874 mg/L for dissolved zinc (based on the maximum values observed in the Eldridge and Wises Pits mixed at the 9:1 ratio);
- A median (monitoring point W2) receiving environment concentration of 0.0025 mg/L for dissolved zinc; and
- A conservative adoption of a 69% utilisation of the dissolved zinc available assimilative capacity; and,
- Maintenance of the same release ratio (0.5%) during the construction phase may result in a slightly greater use of the available assimilative capacity (76%) when water is released solely from the Eldridge pit where the observed maximum concentration of dissolved zinc is 1.75 mg/L.

Consequently, at the proposed release ratio of 0.5%, these assumptions provide additional contingency to allow for possible increases to either the receiving environment or release concentrations releases to continue to meet the dissolved zinc HMTV.

Dynamic adjustment of the release ratio during release events is not practical or intended. The proposed release conditions have been based on conservative, maximum values for dissolved zinc and as long as ongoing monitoring continues to indicate that current concentrations are lower than this, the proposed release conditions will result in significantly less utilisation of the available assimilative capacity. In the event that monitoring indicates that concentrations of key contaminants in the pits significantly increase to the point that exceedance of the maximum values used to determine the proposed release ratio is likely, the release ratio can be adjusted (prior to a release) to ensure utilisation of available assimilative capacity is maintained at an appropriate level.

Table 6 Maximum Observed Concentrations for Release Waters

Parameter	No. of Samples		Maximum Conc. in Eldridge Pit Maximum	Maximum Conc. in Composite Mix[A]	Standard Deviation	
	Eldridge Pit	Wises Pit			Eldridge Pit	Wises Pit
Zinc (F)	8	7	1.75	1.5874	0.585	0.087
Manganese (T)	16	14	3.77	3.622	1.094	0.577
Cadmium (F)	8	7	0.0321	0.02901	0.009	0.0003
Cobalt (T)	19	17	3.840	3.5151	0.853	0.160
Arsenic (T)	20	18	0.260	0.368	0.058	0.294
Cobalt (F)	8	7	0.029	0.0283	0.008	0.007
Nickel (F)	8	7	0.038	0.0352	0.010	0.003
Cadmium (T)	20	18	0.0460	0.04186	0.013	0.001
Lead (T)	19	17	0.190	0.1723	0.042	0
Electrical Conductivity	21	19	4790 µS/cm	5311 µS/cm	732	1593
Arsenic (F)	8	7	0.056	0.1694	0.018	0.394
Molybdenum (T)	19	17	0.100	0.122	0.020	0.105
Sulfate as SO4 - Turbidimetric	21	19	2500	2690	533	652
Nitrate as N	2	2	5.45	4.935	0.160	0.145
Total Phosphorus as P	2	2	0.025	0.0315	0	0.035

Note: Only the 15 parameters requiring the highest level of dilution are listed (refer to Table 54 of the IAR).
[A] Uses maximum pit water concentrations, mixed at a ratio of 9 parts Eldridge to 1 part Wises.

Response 27

Section:

Section 9.1 Monitoring

Review Comment:

Increased water quality and aquatic ecosystem health risks from construction phase proposal would require, if approved, a more comprehensive and responsive monitoring regime. Within the “Overview of Receiving Environment Monitoring Program” Table 109, the upstream and downstream water quality monitoring frequency during releases stipulates a sample is to be taken within the first 24 hours, and then every three days thereafter until one week after the release ceases. Given that Type 1 discharges will not occur at flows less than 400 ML/day, an estimate of how long the minimum flow (plus discharge volume for construction phase 16 ML/day) would take to reach the last downstream monitoring site EG1 is necessary. The proposed monitoring timing/frequency should capture sampling for declining water quality and impacts in relation to the predicted timing of impacts.

The previous comments are still valid.

Pond 4 and the Einasleigh gorge downstream have been removed from the monitoring program in the new IAR.

Copperfield gorge has been added, is this site equivalent to the Einasleigh gorge site?

Potentially groundwater quality monitoring should be included in the monitoring program.

Recommendation:

The approval will need to nominate the relevant indicators, conditions and monitoring points/frequency. Currently this information sits within the REMP document.

The nominated site DS1 is listed as immediately downstream of the mixing zone, however, no clarification of which mixing zone is relevant for this site location has been presented. Further downstream, monitoring is also required with the semi-permanent waterholes Pond 4, Pond 5, and W3 during the construction phase.

Pond 4 has been removed as monitoring will occur at Pond 5. These ponds are so close together that in wet periods it is likely that they will be the one contiguous pond.

Monitoring at Einasleigh Gorge was not removed. There was a name change to Copperfield Gorge - this was done in error and still represents the same location. To clarify, Copperfield Gorge refers to the Copperfield Dam (upstream of the Project site). Where relevant, names have been changed back to the Einasleigh Gorge (refer to Figure E1 included as part of Response 2).

The site DS1 sits immediately downstream of the mixing zone for the Project. The REMP includes regular monitoring at all sites nominated.

Groundwater monitoring is included in the REMP. Refer to the bottom two lines of the table in Appendix A of the REMP. These bores are between the Wises and Eldridge Pits and the Copperfield River and target shallow alluvials, and are therefore appropriate.

2.6 Appendix B Water Quality Statistics Tables

Response 28

Section:

Appendix B Water Quality Statistics Tables

Review Comment:

Appendix B appears to exclude the information more recently obtained from depth profiling within the Eldridge Pit.

Recommendation:

\-

August 2018 pit profiling results are discussed at the end of Appendix C (Pit Profiling) of the IAR.

2.7 Appendix G DTA – June 2018

Response 29

Section:

Appendix G DTA – June 2018

Review Comment:

The most diluted wastewater Rainbow fish embryo hatching assessment (for both DTA 1and DTA 2) shows a trend (although not statistically significant) of more toxicity and much higher variability than less diluted tests. The possible influence of hardness within the DTA dilutions is lacking from the IAR. A written discussion and explanation from Ecotox Pty Ltd in regards to the possibility of a multiple phase dose response should be included in the IAR. The possibility of higher toxicity in more dilute mixtures should be addressed given the well-established influence of water hardness on toxicity. Can the results of the DTA be relied upon to assure that no acute and/or chronic toxicity impacts are posed by the proposal (over a 3 year period of repeated event-based discharges)?

Recommendation:

-

Numerous opportunities were provided for comments on the DTA, from early 2018 onwards. Unless critical to the assessment of the IAR, there is a preference not to have to go back over work which has been submitted for review numerous times already.

2.8 Appendix I Draft REMP

Response 30

Section:

Section 1.0 Aims and Objectives

Review Comment:

Note - An objective of the REMP is also to outline mitigation and measurement measures that would be implemented to further limit potential impacts of the water releases, as suggested in section 7.5.1.

Recommendation:

The IAR should include potential mitigation and management measures that may be implemented in response to monitoring undertaken as part of the REMP to limit impacts of water releases. It should include triggers for the implementation of each mitigation measure.

Adaptive mitigation measures are included within the IAR - Section 9.3. The REMP outlines the monitoring regime to be applied through the construction and operation phases of the Project. Should unacceptable exceedances be found to occur as a result of the Project releases then the proposed mitigation measures will be implemented accordingly to reduce these impacts to acceptable levels.

The REMP is proposed to undertake review of the release regime on a yearly basis in the provision of a REMP Assessment Report. This must be undertaken by a suitably qualified individual and will assess if there are any impacts to the receiving environment as a result of the releases.

A revised REMP has been submitted as part of this supplementary information (Appendix C). Please see Section 4.3 of the revised REMP.

Response 31

Section:

Section 4.1

Review Comment:

Figure 3 is not included in the draft REMP.

Recommendation:

Include Figure 3 to clarify proposed water quality monitoring locations.

This figure was provided in Appendix I (REMP) of the PDF version of the final IAR (without changes tracked) and was also reproduced as Figure 75 of the IAR (Section 9.2). Refer to Figure E1 of this Supplementary information for monitoring locations.

A revised REMP has been submitted as part of this supplementary information (Appendix C). Please see Section 4.3 of the revised REMP.

Response 32

Section:

Section 4.4.2 Assessment Method

Review Comment:

The methodology for assessing aquatic flora and fauna communities is not provided.

Recommendation:

Detail the methodology for assessing aquatic flora and fauna communities.

A revised REMP has been submitted as part of this supplementary information (Appendix C). Please see Section 4.3 of the revised REMP.

Response 33

Section:

Section 6.0 Reporting

Review Comment:

The placeholder in this section indicates that reporting will be completed "as per conditions of EA." Note - the proposed project will not have an EA as it is not an environmentally relevant activity requiring an EA.

Recommendation:

Clearly state here and in other sections of the IAR that no EA approval would be issued for the proposed project as the activity is not an ERA.

Any approval conditions would sit as imposed conditions in the Coordinator-General's Evaluation Report for the proposed project. Compliance with any imposed conditions would be the responsibility of the Office of the Coordinator-General.

A revised REMP has been submitted as part of this supplementary information (Appendix C). Please see Section 4.3 of the revised REMP.

2.9 Additional Clarification Request

On 22nd February, additional clarification requests were received from DES (via OCG). Responses to these clarification requests are provided following.

1. The capacity of the Eldridge and Wises Pits
    - e.g. page 16 of the IAR (11/1) states that Wises Pit can hold approximately 10 GL, but this page also states that the Wises Pit holds 8.5 GL. In Appendix K it states the Wises Pit will have a volume of 8.38 GL following the pumping of water from the Eldridge Pit. Similarly numbers vary throughout the document for the Eldridge Pit volumes.

      The original estimated volume of Wises Pit was approximately 10 GL (as reported as part of early options assessments). Refer to the footnote on page 16 which states that:

      "Note that the following section summarises in part, high level preliminary documentation that utilised contemporary information and data that, in some instances has been subsequently revised and/or updated. For example the current estimated volume of water required to be dewatered from Eldridge Pit is around 28 GL due to additional inflows over the 2017/18 wet season. Similarly, initial estimates of the current capacity of the existing Wises pit have also been refined and are now in the order of 8.5 GL."

      The estimated capacity of 8.5 GL for the existing Wises Pit is the most current.

      It should also be noted that in some cases, rounded numbers are used (e.g. 8.5 GL vs 8.38 GL).

2. The estimated volume of water to be released to the Copperfield River from the Eldridge Pit for construction phase under different rainfall accumulation scenarios
   Annual release statistics for the construction period are presented in Table E2 and Section 7.4.1 (Tables 96 – 98) of the IAR. Refer also to supplementary information Response 9 which presents predicted median and 95th percentile annual release volumes and other relevant statistics.

3. Whether or not any other water may be required to be released during construction – and if yes, what is the source of that water (i.e. Eldridge Pit only or Eldridge + Wises at a dilution ration of 9:1);
   As stated in Response 8, the Optimised Proposed Design was developed to store excess construction water such that releases of excess water are only required to cater for seasonal inflows during both the construction and operational phases under a controlled, event-based release of water from the Project. Refer to Response 5 for a description of sources of water during the construction phase.

4. Confirm the distance from the project site (proposed release point release point) to the start of the Copperfield Gorge at Einasleigh – it varies between 44.25, 44.98 and 50 km downstream (measured as "adopted middle thread distance" of the watercourse)
   The first two numbers describe different features: 44.28 km from the release location to Einasleigh Gorge and 44.98 km from the release location to confluence of Copperfield River with the Einasleigh River. The 50 km is a rounded estimate.

5. Clarify the current volumes of Wises and Eldridge pits following the recent rain events (and any subsequent changes to the construction phase release proposal).
   The current volumes will not be re-calculated. Given that releases will be dependent on future inflows, which will vary from season to season, it is not possible to accurately predict release volumes regardless of the current volumes in the pits. The Optimised Proposed Design was developed to cater for this variance in seasonality and therefore no change to the construction phase release proposal is required. The Project will be operated according to the proposed release conditions, including a 200:1 dilution ratio which has been based on conservative, maximum values for dissolved zinc.

6. That the gorge at Einasleigh is called the Copperfield Gorge and the dam upstream of the project site is called Copperfield Dam – the names still vary within the document
   To clarify, Copperfield Gorge should refer to the gorge located at the Copperfield Dam (upstream of the project area) and Einasleigh Gorge should refer to the gorge near Einasleigh Township.

There were some errors in the IAR where the Einasleigh Gorge was inadvertently referred to as the Copperfield Gorge; these have been corrected in the updated REMP (Appendix C).

7. Confirm quantity of waste rock/virgin rock and total extraction for the construction of Wises Pit (section 4.1.1 states 1.6m3 and 4.2.2.5 states 1.5m3). Confirm the location/use of the quantities e.g. for dam construction, relocation to existing WRD
    - 100,000 m^3 is used for dam construction (part of the existing Proposed Design)
    - 1.5 million m^3 will be relocated to the new waste rock dump the subject of a revised Plan of Operations as part of the Optimised Proposed Design (comprising 1.3 million m^3 of waste rock and 200,000 m^3 of virgin rock).

8. Table 3 identifies construction phase from 2019-2022. Confirm timing for all construction activities in months/years.
   The duration of the construction phase will be 42 months from commencement. It is anticipated that commencement will occur in June/July 2019.

3.0 Additional Surface Water Sampling (February 2019)

3.1 Purpose

Existing baseline data for the Copperfield River (as presented in the IAR) identified elevated values of total nitrogen in the receiving environment, however this assessment is based on a very limited number of samples. Additional water quality sampling was undertaken in February 2019 to further describe nutrient concentrations at upstream and downstream locations form the Project (particularly during and following periods of flow) and to provide additional information to address risks of algal blooms and elevated nutrients in the receiving environment as a result of releases.

3.2 Methodology

Samples were taken in accordance with the Monitoring and Sampling Manual (2018) by site personnel who were instructed in sampling methodologies by AECOM staff.

The following sites were targeted for sampling:

- WB
- W1
- W2
- W3
- Einasleigh Gorge.

This monitoring event was the first time samples were obtained from the Einasleigh Gorge.

Field pH, EC and temperature readings were obtained for each site. Each sample was analysed by SGS (a National Association of Testing Authorities accredited laboratory) for the following parameters:

- Electrical conductivity (EC)
- Ammonia
- Nitrate
- Nitrite
- Nitrate+Nitrite
- Total Kjeldahl Nitrogen (TKN)
- Total Nitrogen
- Total Phosphorous
- Filterable Reactive Phosphorous (FRP).

Certificates of Analysis are found in Appendix D.

For statistical analysis, all values that were below the limit of reporting (LOR) were transformed to 50% of the LOR (e.g. <0.005mg/L became 0.0025mg/L).

3.3 Weather Conditions

Flow is approximated by the DNRM stream gauge “Copperfield River at Spanner Waterhole” (917115A) which is installed upstream of the Copperfield Dam. Stream flow and rainfall records from this gauge are shown below in Figure 9.

Significant flow had occurred prior to the sampling event, cutting off the site and meaning that access was not possible for a period of time. This was the result of successive intensive rainfall for a period of four days between 30 January and 2 February 2019.

Sampling commenced on 11 February 2019, once safe access was provided to monitoring points. The river had a flow rate of approximately 4,000ML/d on 10 February 2019, gradually reducing to 1,000ML/d on 19 February 2019.

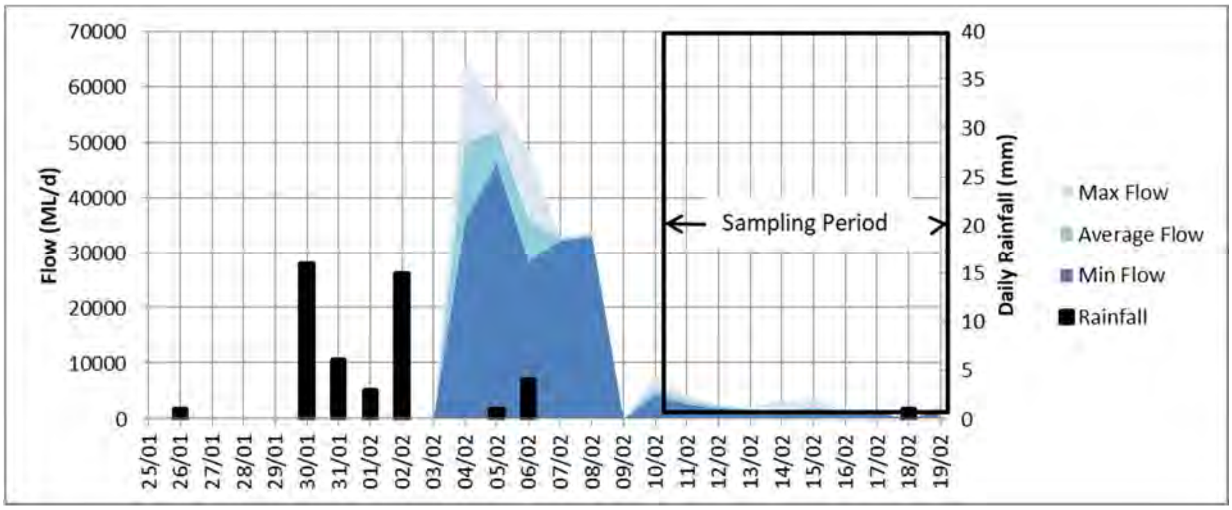

Figure 9 Rainfall and stream flow at the Copperfield River at Spanner Waterhole DNRM Gauge (917115A)

3.4 Results

3.4.1 Sample Numbers and distribution

Table 7 shows the total number of samples acquired over the sampling event. There were nine samples collected for WB (the upstream location), W1 and W2. There were only eight samples collected for W3 and the Einasleigh Gorge (EG).

Table 7 Number and distribution of nutrient samples for the Copperfield River

Date	WB	W1	W2	W3	EG	Total
11/02/2019	1	1	1	1	1	**5**
12/02/2019	1	1	1	1	1	**5**
13/02/2019 AM	1	1	1	1	1	**5**
13/02/2019 PM	1	1	1	1	1	**5**
14/02/2019	1	1	1		1	**4**
15/02/2019 AM	1	1	1	1	1	**5**
15/02/2019 PM				1		**1**
16/02/2019	1	1	1	1	1	**5**
17/02/2019	1	1	1	1	1	**5**
19/02/2019	1	1	1	1		**4**
Total	**9**	**9**	**9**	**9**	**8**	

3.4.2 Raw Water Quality Statistics

Percentile data were calculated for each parameter and are provided below in Table 8.

3.4.3 Possible Outliers

Comparison between field EC and lab EC data shows that there are two possible outliers, both from the W2 site (Figure 10). The W2 sample on 11th February shows a high laboratory EC value (1600 µS/cm) compared to its field EC value (116 µS/cm). The W2 sample on 13 February 2019 shows a high field EC value (767 µS/cm) compared to its laboratory EC value (82 µS/cm).

The laboratory EC value for the 13 February 2019 sample (82 µS/cm) fits within the range of EC values recorded at the site from other sampling events, therefore this value was retained. However, the high laboratory EC value on 11 February 2019 (1600 µS/cm) does not fit within the range of other sampling events and does not agree with the field value (116 µS/cm). This sample also shows unusually high concentrations of total nitrogen, nitrate, nitrite and NOx (nitrate + nitrite) compared to data on subsequent days. Therefore this sample was discarded from the dataset and statistics were re-calculated. Revised statistics for the W2 site with the 11 February 2019 sample removed, are input into Table 8 as W2*.

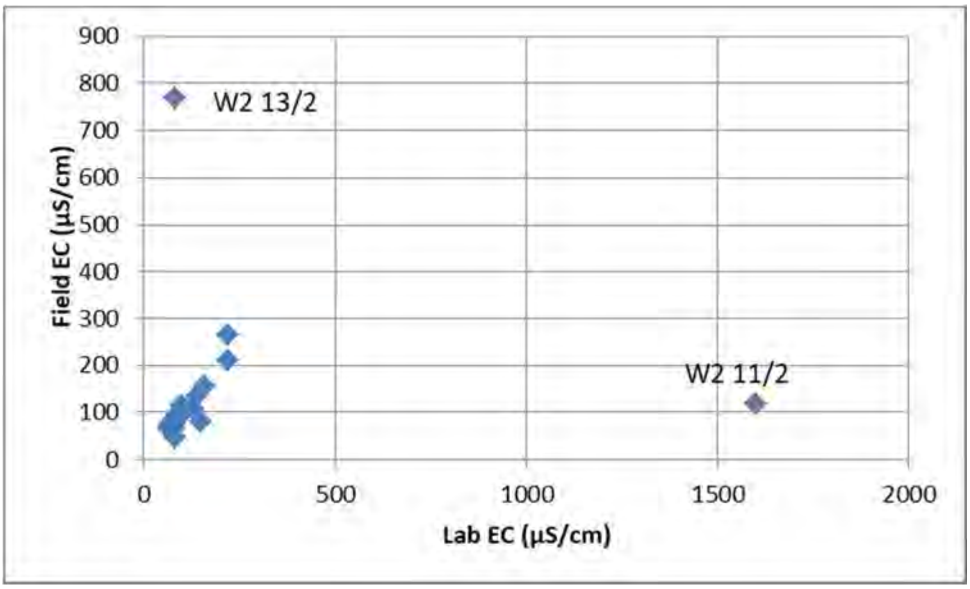

Figure 10 Analysis of field EC vs lab EC

Table 8 February 2019 water quality statistics for each nutrient parameter analysed

Variable	Site	Num Obs	Minimum	20%ile	50%ile	80%ile	95%ile	Maximum	Mean	SD
Ammonia	WB	9	0.0025	0.0025	0.0025	0.0025	0.049	0.08	0.0111	0.0258
	W1	9	0.0025	0.0025	0.0025	0.0025	0.0112	0.017	0.00411	0.00483
	W2	9	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	W2*	8	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	W3	9	0.0025	0.0025	0.0025	0.0025	0.0046	0.006	0.00289	0.00117
	EG	8	0.0025	0.0025	0.0025	0.0025	0.00543	0.007	0.00306	0.00159
Electrical Conductivity	WB	9	75	86.8	130	148	196	220	124.6	46.18
	W1	9	67	69.6	73	76.8	78.6	79	73.11	4.076
	W2	9	73	81.6	88	148	1048	1600	269.9	500.8
	W2*	8	73	81.4	87	99.6	178	220	103.6	47.88
	W3	9	70	72.2	77	79.4	81.2	82	76	4.093
	EG	8	77	79.2	83.5	94.4	132.5	150	92.38	24.35
FRP	WB	9	0.0025	0.0025	0.005	0.006	0.0072	0.008	0.00483	0.00195
	W1	9	0.005	0.007	0.008	0.0102	0.0126	0.013	0.00844	0.00255
	W2	9	0.006	0.007	0.008	0.0114	0.0162	0.019	0.00967	0.004
	W2*	8	0.006	0.007	0.008	0.0108	0.0166	0.019	0.0095	0.00424
	W3	9	0.006	0.0066	0.007	0.0122	0.0146	0.015	0.009	0.00346
	EG	8	0.006	0.0094	0.011	0.0132	0.0153	0.016	0.0111	0.00304
Nitrate	WB	9	0.0025	0.0052	0.011	0.0144	0.021	0.025	0.0109	0.00702
	W1	9	0.0025	0.0025	0.006	0.0114	0.0282	0.037	0.00944	0.0112
	W2	9	0.0025	0.0066	0.008	0.0304	0.435	0.69	0.0885	0.226
	W2*	8	0.0025	0.0064	0.0075	0.0128	0.0394	0.052	0.0133	0.0161

Variable	Site	Num Obs	Minimum	20%ile	50%ile	80%ile	95%ile	Maximum	Mean	SD
	W3	9	0.0025	0.0025	0.008	0.0222	0.0396	0.046	0.0136	0.0151
	EG	8	0.0025	0.0025	0.01	0.034	0.0511	0.056	0.0184	0.0204
Nitrate + Nitrite	WB	9	0.0025	0.0062	0.011	0.0148	0.0214	0.025	0.0113	0.00677
	W1	9	0.0025	0.0025	0.007	0.0124	0.0292	0.038	0.0102	0.0113
	W2	9	0.0025	0.007	0.009	0.0314	0.435	0.69	0.0892	0.226
	W2*	8	0.0025	0.007	0.0085	0.0138	0.0404	0.053	0.0141	0.0162
	W3	9	0.0025	0.005	0.008	0.0232	0.0412	0.048	0.0149	0.0152
	EG	8	0.0025	0.0025	0.0115	0.0356	0.0525	0.057	0.0193	0.0208
Nitrite	WB	9	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	W1	9	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	W2	9	0.0025	0.0025	0.0025	0.0025	0.0052	0.007	0.003	0.0015
	W2*	8	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	W3	9	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
	EG	8	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0
Organic Nitrogen	WB	9	0.24	0.272	0.4	0.606	0.768	0.8	0.44	0.207
	W1	9	0.19	0.232	0.32	0.398	0.422	0.43	0.31	0.0875
	W2	9	0.16	0.216	0.31	0.338	0.398	0.43	0.286	0.0871
	W2*	8	0.16	0.204	0.275	0.33	0.343	0.35	0.268	0.0729
	W3	9	0.14	0.206	0.26	0.41	0.662	0.77	0.328	0.198
	EG	8	0.18	0.184	0.215	0.286	0.29	0.29	0.23	0.049
TKN	WB	9	0.24	0.276	0.4	0.638	0.8	0.8	0.45	0.22
	W1	9	0.2	0.232	0.33	0.398	0.422	0.43	0.313	0.0863
	W2	9	0.16	0.216	0.32	0.338	0.398	0.43	0.287	0.0875

Variable	Site	Num Obs	Minimum	20%ile	50%ile	80%ile	95%ile	Maximum	Mean	SD
	W2*	8	0.16	0.204	0.28	0.33	0.343	0.35	0.269	0.0738
	W3	9	0.14	0.21	0.26	0.414	0.672	0.78	0.331	0.201
	EG	8	0.18	0.19	0.215	0.286	0.29	0.29	0.231	0.0476
Total Nitrogen	WB	9	0.24	0.292	0.41	0.648	0.816	0.82	0.463	0.221
	W1	9	0.2	0.236	0.35	0.402	0.432	0.44	0.322	0.0902
	W2	9	0.16	0.23	0.32	0.348	0.804	1.1	0.373	0.281
	W2*	8	0.16	0.22	0.305	0.34	0.353	0.36	0.283	0.0727
	W3	9	0.15	0.222	0.28	0.424	0.676	0.78	0.347	0.197
	EG	8	0.19	0.198	0.235	0.296	0.333	0.35	0.25	0.0583
Total Phosphorous	WB	9	0.01	0.022	0.04	0.054	0.072	0.08	0.0411	0.0226
	W1	9	0.01	0.022	0.03	0.044	0.05	0.05	0.0322	0.0148
	W2*	8	0.01	0.018	0.035	0.04	0.04	0.04	0.03	0.0131
	W2	9	0.01	0.022	0.04	0.04	0.04	0.04	0.0311	0.0127
	W3	9	0.01	0.016	0.03	0.044	0.05	0.05	0.0311	0.0154
	EG	8	0.01	0.03	0.04	0.04	0.0465	0.05	0.035	0.012

* Values have been calculated based on removal of an outlier as discussed in Section 3.4.3.

3.4.4 Discussion

The 80th percentile is elevated above the default WQO for:

- Total nitrogen
- NOx (nitrate + nitrite)
- Total phosphorous
- Filterable reactive phosphorous.

A discussion on these parameters is outlined below. Please note that this discussion includes removal of the 11 February 2019 sample from the W2 record as outlined in Section 3.4.3.

3.4.5 Total Nitrogen

Total nitrogen values from all samples for all sites are elevated above the default WQO of 0.15 mg/L, which is based on ANZECC/ARMCANZ 2000 default WQOs for upland rivers in Tropical Australia (Figure 11). Total nitrogen values are elevated at the WB upstream site compared to downstream sites. The 80th percentile of the values from WB is equal to 0.648mg/L, approximately 6 times higher than the WQO. These results are consistent with previous concentrations reported in the IAR.

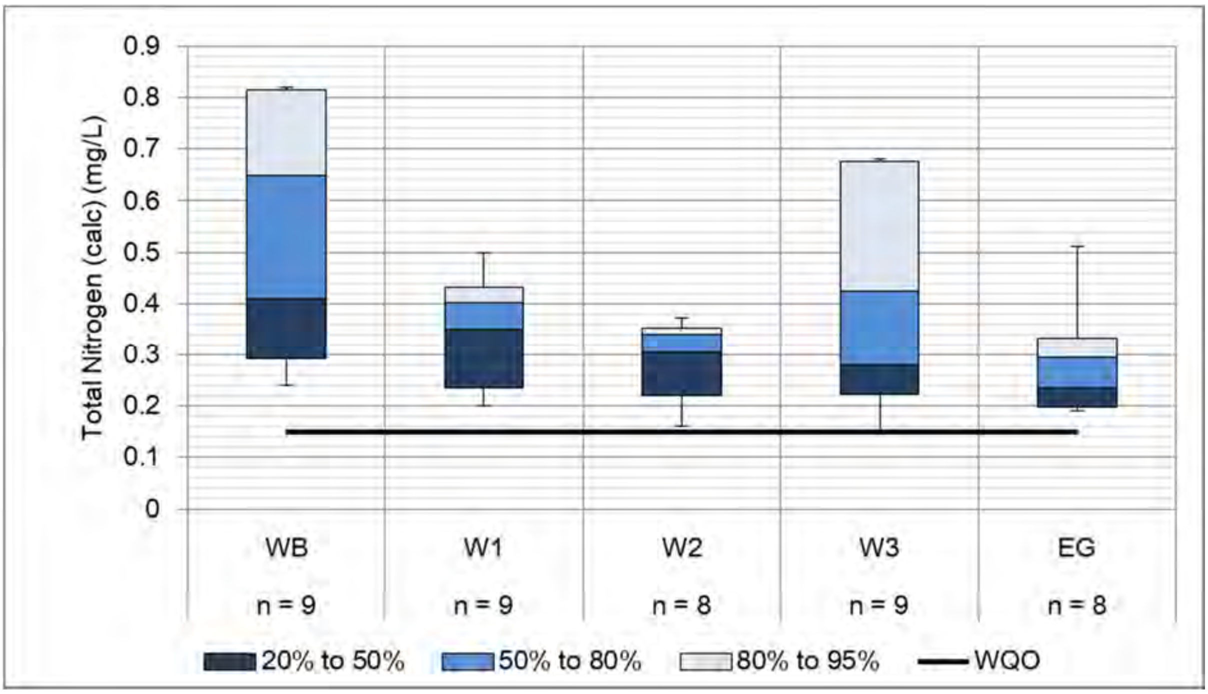

Figure 11 Water quality statistics box-plot for total nitrogen

The WQO for Total Nitrogen is sourced from the ANZECC Guidelines for Tropical Australia for upland water types. The ANZECC (2000) Guidelines note that this value may not be suitable for inland or ephemeral streams. Based on the data obtained it is apparent that the WQO for upland streams is not suitable.

The Copperfield Dam will influence the levels of nitrogen in the Copperfield River. Organic matter will accumulate and decay in the dam over the dry season. Significant rainfall during a wet season will cause the dam to overflow, flushing this organic matter and nutrients into the system downstream. Values at the Einasleigh Gorge are also elevated above the WQO of 0.15mg/L. There is an overall decreasing trend in total nitrogen values from 11 February to 17 February 2019 with an increase in all samples on 19 February 2019 (Figure 12). The records from WB have the highest variability of all sites in the time series record (Figure 12).

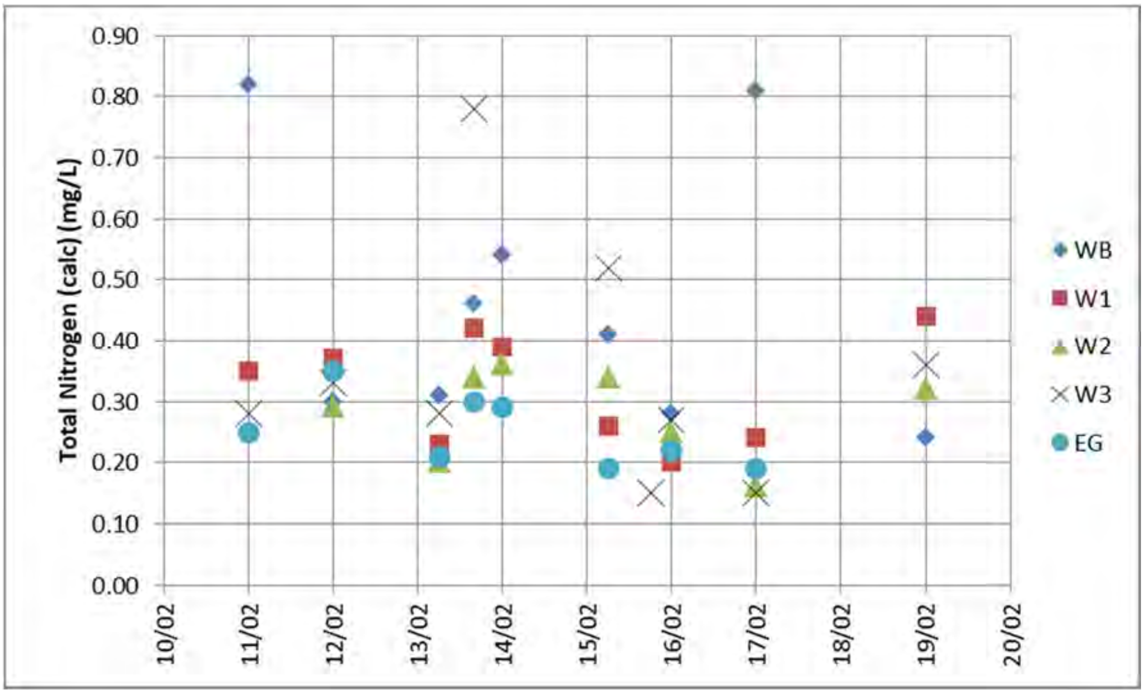

Figure 12 Water quality time series for total nitrogen from all sites

3.4.6 NOx (Nitrate + Nitrite)

NOx as N represents the total concentration of nitrate and nitrite in the system. The default WQO is derived from the ANZECC (2000) guidelines in a similar manner to total nitrogen and total phosphorous. The WQO for NOx (0.03mg/L) is a generic value that is applied to all tropical Australian upland freshwaters.

The 80th percentile for the Einasleigh Gorge (0.035mg/L) slightly exceeds the default WQO for NOx as N (0.030mg/L), however is below the WQO at WB, W1, W2 and W3.

Data collected from the Einasleigh River at Einasleigh DNRM gauge (917106A) show an 80th percentile of NOx values (field filtered) of 0.018mg/L from 21 data points between 2006 and 2018. This data is expected to be lower as it has been field filtered whereas the data collected for this study has not.

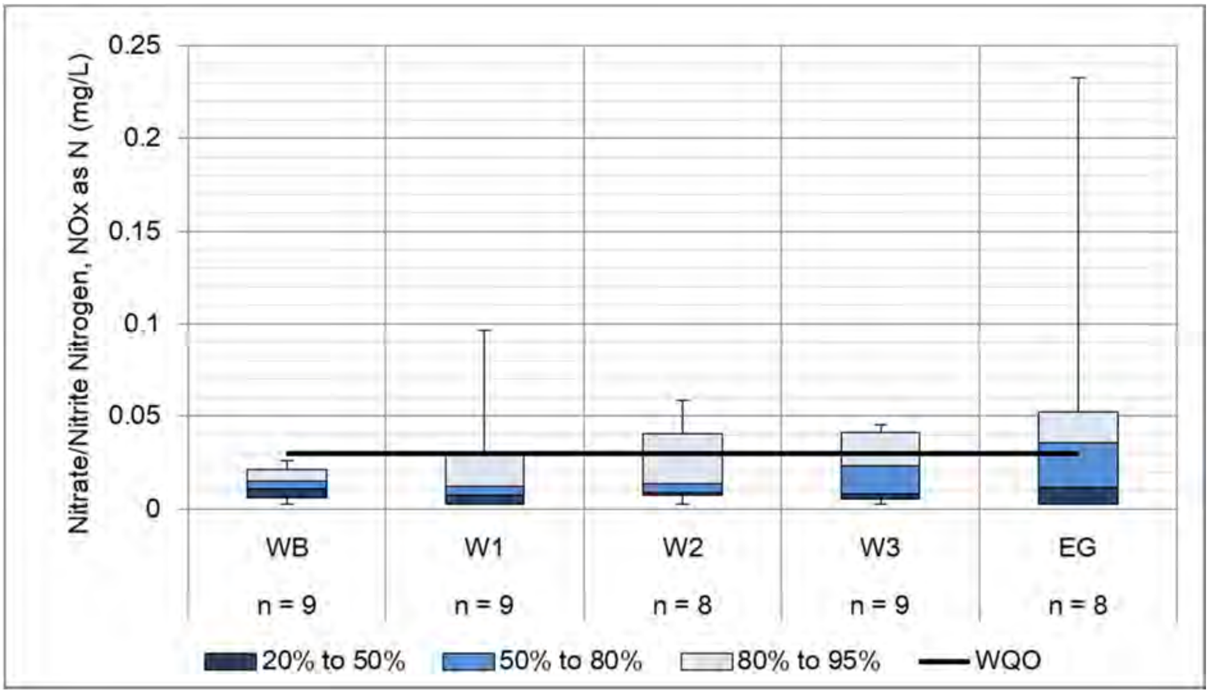

Figure 13 Water quality statistics box-plot for NOx

3.4.7 Total Phosphorous

All samples show a total phosphorous concentration above the default WQO for upland streams of 0.01mg/L for all samples (Figure 14). Total phosphorous is elevated at upstream sites compared to downstream sites. Similar to total nitrogen, the WQO for total phosphorous is sourced from the ANZECC guidelines for upland streams and several caveats are applied. Data from the sampling event suggest that the WQO is not suitable for application to the Copperfield River as all samples are above this value.

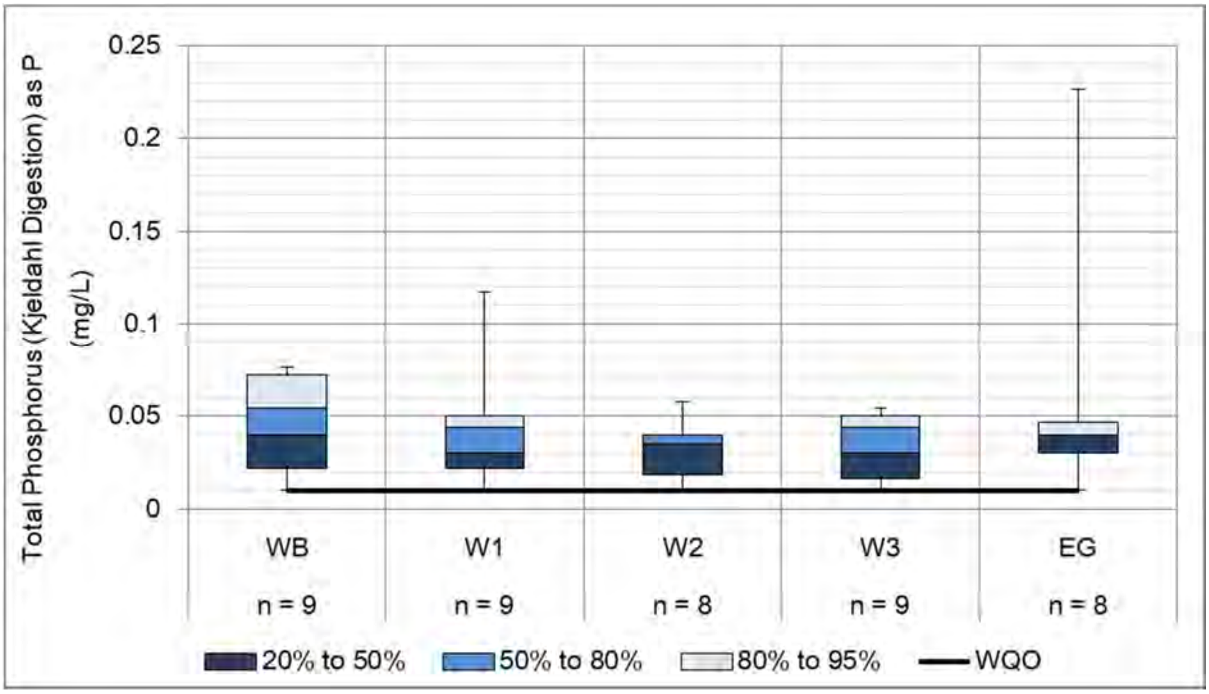

Figure 14 Total phosphorous box plot

3.4.8 Filterable Reactive Phosphorous

Like total nitrogen and total phosphorous, the WQO for FRP (0.005mg/L) is based on ANZECC (2000) default values for upland streams. Box plots of relevant statistics for FRP are shown below in Figure 11. FRP values appear to increase with distance downstream along the catchment with the lowest values and range recorded at WB (80th percentile of 0.006mg/L) and the highest values recorded at the Einasleigh Gorge (80th percentile of 0.0132mg/L). This is not an impact occurring from the historic mining activities at Kidston as the Einasleigh Gorge receives significant flows from the Einasleigh River, and the impact is not expected to be detectable at this location.

The Einasleigh River at Einasleigh DNRM gauge (917106A) shows a FRP 80th percentile of 0.018mg/L which agrees with the data collected as part of this study. Subsequently it is believed that sources of FRP are likely to occur from the surrounding catchment geology.

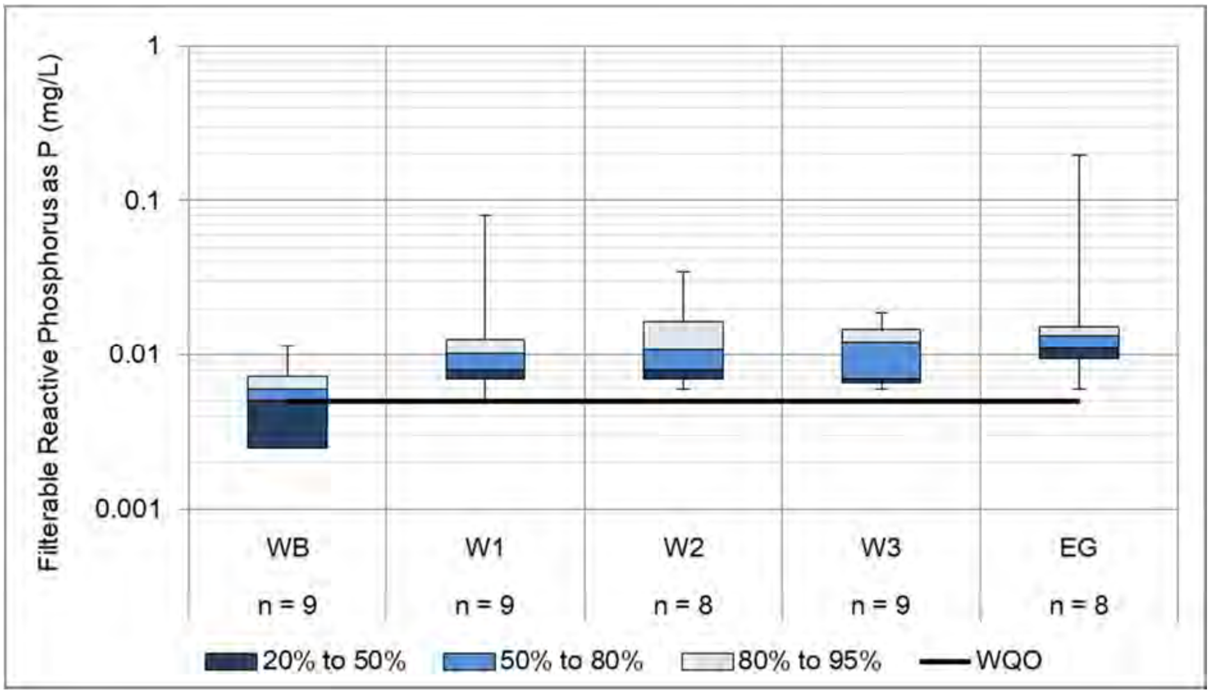

Figure 15 Water quality statistics box plot for FRP

It appears that sources outside the Copperfield may be influencing concentrations at the Einasleigh Gorge. It is also apparent that the ANZECC default WQO of 0.005mg/L is not suitable for the Copperfield or Einasleigh Catchments.

3.5 Conclusions

Water sampling was undertaken between 11 February 2019 and 19 February 2019 to gather eight or nine samples from receiving environment sites as well as the Einasleigh Gorge to add further data on baseline concentrations of nutrients in the Copperfield River. The data indicates that default WQOs for total nitrogen, NOx, total phosphorous and FRP are unsuitable for application to the catchment. Since there are no WQOs derived in the Queensland Water Quality Guidelines for Gulf Catchments, these WQO's are derived from the ANZECC (2000) guidelines for upland freshwaters for all of Tropical Australia. The ANZECC (2000) guidelines state that these values may not be suitable for application to ephemeral streams. Data collected during this assessment shows naturally elevated concentrations above these values. This was supported by long-term gauge data from the Einasleigh River where available.

Ongoing sampling for nutrients in the receiving environment is proposed to be undertaken as per the REMP (Appendix C), with a view to developing site-specific WQOs once sufficient data is available.

4.0 References

AECOM Australia Pty Ltd 2019. *Kidston Pumped Storage Hydro Project Impact Assessment R*eport. Prepared for Genex Power Ltd, 11 January 2019.

Chessman, B.C. (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research*. **54:** 95-103.

Appendix A

Comments Register

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
IAR						
Executive Summary	Receiving Environment	No evidence is provided to confirm that Middle Spring is not hydraulically connected to the groundwater regime of the proposed release area.	Provide evidence to support the assertion that the Middle Spring is not hydraulically connected to the proposed release area groundwater regime. If this evidence is not available, connection between Middle Spring and local groundwater should be assumed.	DES has previously commented on the lack of evidence in the IAR to support the assertion that Middle Spring is not hydraulically connected to the groundwater regime of the proposed release area. In response, the proponent has agreed to assess potential connectivity as part of "water modelling refinement and design phase work", however, this information should be provided in the IAR.	Update the IAR to include evidence to support the assertion that the Middle Spring is not hydraulically connected to the proposed release area groundwater regime. In the absence of this evidence, hydraulic connection between Middle Spring and local groundwater should be assumed.	Current field sampling will attempt to obtain water samples from Middle Spring to compare to pit water quality samples previously undertaken to determine hydraulic connectivity. If water samples are unable to be collected then it is proposed that monitoring be undertaken through the REMP.
Executive Summary	Operational/Construction Releases	This section should state the likely volume of water that would need to be released during construction and continued operations.	State the volume of water that would be released during construction and continued operations.	No further comments		
Executive Summary				(new comment) The location of many features referred to in the Executive Summary is unclear in the absence of a map, for example Chinaman Creek.	Include a map in the Executive Summary or the front end of the document to clarify the location of features discussed in the Executive Summary.	New map to be created and included in supplementary information.
Executive Summary	Construction Releases	Specific detail regarding the number of days per year over which releases may occur should be included, for example, the likely minimum and maximum number of release days.	At a minimum, include the minimum and maximum number of days over which water will be released during the construction period.	No further comments		
Executive Summary				(new comment) The IAR states that "In reality the actual assimilative capacity usage will be lower than 76.3% in most cases." The IAR should present a realistic summary of likely releases.	Amend the IAR to provide a realistic summary of construction releases.	The 76.3% usage of assimilative capacity is based on the maximum concentration of dissolved zinc in Eldridge Pit. Assimilative capacity usage for P50 dissolved zinc concentration in Eldridge Pit is approximately 34%. Assimilative capacity usage for P80 dissolved zinc concentration in Eldridge Pit is approximately 57%. This data will be provided with supplementary info.
Executive Summary	Hydraulics and Fluvial Geomorphology Impacts for Temporary Construction Releases	Visual inspections during construction releases are proposed to identify erosion and scouring at the release location. However, no information is provided to indicate what level of erosion of scour or erosion would be deemed unacceptable - noting that underwater scouring will not be visible. Furthermore, no mitigation measures are identified to limit the impacts of unacceptable levels of erosion and scouring - noting that once erosion or scour is identified it may be too late to intervene to ensure further erosion or scouring is limited or prevented.	The IAR should describe: 1) how unacceptable erosion or scouring will be defined 2) how underwater scouring would be identified 3) suitable mitigation measures that would be implemented to limit/prevent further scouring or erosion 4) whether water releases would cease or be slowed to limit the potential impacts of erosion or scouring.	No further comments		
				(new comment) The 4th dot point in this section discusses the sensitivity of the Copperfield River macroinvertebrates communities to environmental change, however, there is little discussion of why then these sensitive communities are not predicted to be impacted by operational water releases.	Include additional information detailing why sensitive macroinvertebrate communities will not be impacted by operational releases.	Macroinvertebrates are used as an indicator organism and are not a protected specie. As outlined in the REMP it is proposed to monitor water quality, sediment quality, groundwater quality, aquatic flora and aquatic fauna (macroinvertebrates) to determine risks of impacts from the Project under multiple lines of evidence. The sensitivity of macroinvertebrate families to environmental change was determined based on their SIGNAL grade (Chessman, 2003). Toxicity data for each potential contaminant relevant to each sensitive family is not widely available, therefore sensitivity within the report is discussed in generalised terms and broadly in relation to environmental change. Sensitive macroinvertebrate families are generally those from the orders Plecoptera, Ephemeroptera and Trichoptera (PET) families. The point made in the Executive Summary refers to these families, rather than the whole macroinvertebrate assemblage/community. The presence of sensitive macroinvertebrate families in the receiving environment (as outlined in the 2018 Aquatic Ecology assessment by C&R Consulting) indicates that the current environment is in relatively good health as these sensitive families are present within the community. Further, the sensitivity of the macroinvertebrate community to environmental change make them an ideal monitoring tool for determining if releases from the site have impacted the aquatic
4.1.1	Construction Phase	HDPE liners may leak if damaged during or after installation. Suitable mitigation measures should be described that would minimise the likelihood of any damage and also limit potential environmental impacts should the HDPE liner be damaged and leak.	Include suitable mitigation measures to minimise the likelihood of damage to the HDPE liner and limit the potential impacts to environmental values should the HDPE liner be damaged and leak.	No further comments		
4.1.2	Release Infrastructure	Table 2 details that "releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises". However, Table 81 only details releases to the river from Eldridge pit.	Provide details/clarity around when releases during construction will occur from a mixed scenario, and how a 9:1 mixture would be achieved prior to commissioning.	The previous comments are still valid		The IAR has considered releases from both the Eldridge Pit directly, or a 9:1 mixture of the Eldridge: Wises pit. During operation, when a 9.1 release is predicted to occur, the Wises pit will have been filled with the Eldrige pit water and natural mixing of these waters would have occurred throughout the period during which the water was transferred between the pits.
4.1.2	Release Infrastructure	This section does not describe the rationale for the location of the release infrastructure.	This section should clearly describe why this release location was chosen. Describe how this location maximises the avoidance and mitigation of potential impacts to environmental values of the land and Copperfield River.	The previous comments are still valid		The proposed location of the release infrastructure was mainly driven by physical and heritage constraints. Most of the alignment falls within a landscape that has been modified by the historic mine operations. At this stage of design, a corridor has been nominated. It is proposed that the release infrastructure will be built within the corridor, but what the exact location will allow future micro sighting to avoid any significant environment values should they be identified during construction works.
4.2.2	Design Refinement and Assessment of Alternatives	Costs estimates for in-pit treatment or RO treatment and release have been undertaken on 17.5 and 12 gigalitres (GL), respectively (Table 4). Given the WQO risks identified in Chapter 7 from 1:25 discharge proposal, these costs should also be presented for the latest predicted construction volume (1.5 -2 GL). Queensland Water Quality Guidelines state there is a need to justify that achieving water quality objectives (based on ANZECC toxicity guidelines) is economically or technically unacceptable before relaxation of the objectives (QWQGs Section 5.3).	Without a reliable assessment of the economics and feasibility of the various possible treatment options for the construction phase predicted volume (1.5 -2 GL) the temporary alteration (3 years) of water quality objectives to <80% species protection for 50 kms of the Copperfield cannot be thoroughly assessed.	This has now been addressed in part as the new Design Option 5, proposes to increase the capacity of Wises Pit to minimise discharge volume during construction.	The IAR should detail all options that were considered, including for example irrigation, additional containment within expanded pit, construction of an additional storage facility.	A number of options have been considered and the best approach is the currently proposed additional storage. Further information can be provided in the supplementary information.
4.2.2	Design Refinement and Assessment of Alternatives	Options for treatment or alternative disposal of the remaining 1.85 – 2.56GL of excess construction water are not proposed.	This section should include a discussion of options for addressing the 2.56GL. Disposal to waters should only be considered after other all alternative re-use, recycling and treatment options have been utilised.	Unclear in this section whether a release during construction is required as the additional water storage volume is 2.5 GL which is greater than the predicted volume to be discharged during construction.	Clarify construction release requirements in this section.	To be clarified in supplementary information.

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
4.2.3				Table 5-Step 2, Waste Prevention. The first paragraph of this column is misleading as it infers that the volume of water to be released has been reduced to zero. This is in fact not that case.	Amend this section to refer to the volume of water requiring release during construction and operations.	To be clarified in supplementary information.
4.7.2	Release Event Type 2 – Pass-Through Discharge	This section states that the "rapidity of any potential mixing has not been estimated as it is likely that the incident rainfall will remain at least partially separated from the higher density pit water during a pass through discharge event." Nonetheless, the quality of water to be released during a Type 2 release is not adequately described. A quantitative assessment of the impact of this type of release must be included in the IAR to allow for a full assessment of it's potential impact and acceptability.	Include a full and detailed description of the likely quality of water that would be released during a Type 2 release. Include a comprehensive detailed quantitative assessment of the likely impacts of this type of release on water quality and environmental values downstream of the release location.	No further comments		
4.7.2	Release Event Type 2 – Pass-Through Discharge	Type 2 pass-through discharges have not been assessed for causality, frequency, discharge volume or quality.	If approval is sought relating to a pass through discharge, a quantitative assessment needs to be undertaken	No further comments		
5.11.12		This section describes potential for changes in groundwater levels to occur in the vicinity of potential GDEs and the need for additional work to determine if these changes will negatively impact vegetation communities. This described additional work should be included in the IAR.	Include in the IAR an assessment of the potential impacts of changes in groundwater levels on GDEs and vegetation on site and downstream of the project.	No further comments		
5.6.3	Sulfate	Sulfate is considered 'high risk' given its historical exceedances of the default WQO for recreation. In risk assessment as "Hydrogeochemical modelling of the predicted water quality at the Gorge suggests, however, that mineral precipitation is not expected beyond that already associated with the (pre-release) Copperfield River."	Mentioned twice in risk assessment (Table 107), but not further described. IAR needs to discuss why sulfate is considered high risk in detail.	No further comments		
6.1.1.2	Dilution Ratio for Adoption	This section describes the use of up to 69% of the receiving environment's assimilative capacity during operational releases. It is expected that during the wet season some assimilative capacity may already be taken up by overtopping of the Kidston tailing dams and other inputs of runoff from the Kidston site. The assimilative capacity of the receiving environment used by the current development, excluding the proposed water releases, should be described in full in this section. The cumulative impact of all inputs (including the proposed construction and operational releases) from the project into the Copperfield River must also be more concisely discussed.	This section should include an comprehensive analysis of the assimilative capacity of the receiving environment already used by the current Kidston Development, including stormwater runoff and tailing dams overtopping during the wet season. It should also include a more detailed quantitative analysis of the potential cumulative impacts of all inputs from the site into the Copperfield River (including the proposed construction and operational releases).	The previous comments are still valid		The assessment of assimilative capacity usage and surface water quality impacts associated with releases are based on historical data from the Copperfield River at monitoring location W2 and therefore take into account the potential seepage impacts as a 'worse case' scenario.
6.2	Water Quality Impact Assessment	The proposed risk assessment for operational phase-controlled discharges predicts that environmental values are unlikely to be adversely impacted by the modelled minimum 1:200 dilution. It is important to highlight that while the impacts assessment was undertaken using a 1:200 dilution design approach, for the purposes of regulation, the operational phase CG approval conditions will require end of pipe limits for the identified important physico-chemical indicators and toxicants, and conditioning around the minimum stream flow and discharge quantities (as well as monitoring frequencies defined). Maximum EOP limits for toxicants need to be derived from the assumptions around inputs used in the impact assessment predictions. Increasing the EOP limits well above the numbers used within modelling represents a higher risk prospect.		No further comments		
6.2.1	Near Field Mixing Zone Assessment (CORMIX)	The near field mixing assessment has returned a result suggesting that the mixing zone where WQOs are not met will be mostly less than 135 m distance downstream (worst case 623 m, in 2% natural flow conditions), and at the minimum release flow trigger the mixing zone is estimated as 51 m distance downstream and a stream width 32 m. While the physical dimensions of the mixing zone based on minimum DTA dilutions has not been assessed specifically, this is anticipated to be a much smaller distance than based on WQOs. However, the dilutions identified in both DTAs do not represent worse case given the water quality assessed was based on composite samples, rather than 100% Eldridge pit. The near field mixing assessment for the operational phase is acceptable.		There is a potential risk of algal blooms within the mixing zone. With the concentration of total nitrogen in the release water 43 times, nitrate 7 times and total phosphorus 3 times the WQO. The nutrient load to the system will also be increased due to the release.	Assess the potential for algal blooms within near field mixing zone.	Refer to separate response regarding risk of algal blooms
6.2.2.5				The conclusion in the Section 6.2.2.5 does not appear to be entirely correct. The concentration of dissolved zinc under the worst case scenario is greater than the WQO at all locations, including the release point and East Gilbert Creek in Table 65.		Review comment is incorrect. The concentration of dissolved zinc under the worst case scenario does not exceed the hardness-modified trigger value (HMTV) at the release point or East Creek. It was long ago agreed with DES that it is appropriate to apply the HMTV (rather than the default WQO) within this zone. As stated in Section 5.6.1 "The median hardness in the receiving environment at W2 is 56 mg/L, therefore the procedure outlined in Section 3.4.4 of the ANZECC/ARMCANZ 2000 ('Applying guideline trigger values to sites'), was applied, using a hardness value of 56 mg/L. This is considered to be a conservative estimate of the trigger value, as once mixed with the release water (median hardness of 1374 mg/L) the hardness will be higher than 56 mg/L, thereby resulting in a higher HMTV ."

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
6.2.3	Assessment of Water Quality Impacts to Environmental Values	Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc.	The document needs to detail what the exceedance may cause – i.e. it currently does not discuss/explore the possibility of increased turbidity/residence time in the creek/Einasleigh Gorge etc. – for neither the construction phase or operations phase Needs to discuss the potential increase in releases from rest of Kidston Mine Site in high rainfall events, which has historically resulting in WQO exceedances	The concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream. The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus. However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular in semi-permanent pools downstream.	Include release of Total P from the pits as a source of phosphorus.	Refer to separate response regarding risk of algal blooms
6.2.3				(new comment) The impact assessment makes mention of photographic monitoring of the release point to monitor erosion or deposition, but does not mention potential mitigation measures to avoid or minimise erosion of deposition.	Include mitigation measures to assist in the avoidance and minimisation of erosion or deposition at the release point.	A discussion regarding the risk of erosion/deposition (including design mitigation measures) is presented in Section 6.5.2 (Fluvial Geomorphology).
6.2.1.5				(new comment) This section mentions "other modelled scenarios". Verify that this modelling is also included in the IAR. If it is not currently included, it should be.	Confirm "other modelled scenarios" are included in the IAR. If not, amend the IAR to include these other scenarios.	This should be considered in the context of the surrounding text. The maximum mixing zone distance for the modelled scenarios is 623 m (Scenario 2). Other modelled scenarios (i.e. Scenarios 1, 3 and 4) indicate a much smaller mixing zone.
6.2.4	Conclusions of Water Quality Impact Assessment	Approval conditions will need to ensure that operational and construction discharge conditions are mutually exclusive and do not co-occur, given that no section of the IAR has assessed the potential for concurrent discharges. In addition, regulatory receiving environment triggers are most likely required, rather than simply being part of a non-specific REMP condition. Triggers and sampling location should reflect modelling output predictions.		No further comments		
6.2.4	Conclusion of Water Quality Impact Assessment	The second dot point in this section describes mixing within 625m as "rapid". The department does not agree with is statement - mixing over this distance should not be described as rapid.	Reword the description of mixing within 625m as "rapid mixing".	No further comments		
6.2.4	Conclusion of Water Quality Impact Assessment	An estimated 625m mixing zone is larger than most approved mine water release mixing zones. Additional measures should be examined to reduce the length of the mixing zone.	Describe additional measures to reduce the release mixing zone.	No further comments		
				(new comment) Potential entrainment and contamination of sediments in the mixing zone has not been addressed.	Include potential for sediment contamination in risk assessment.	Sediment investigation will be undertaken as part of REMP to characterise and compare upstream/downstream sediment quality . Outcome of this investigation will detail actions/mitigation strategies should unacceptable impacts be determined. The concentrations of metals in the release water, although exceeding WQOs, are not very high compared to other industries and mining activities. Therefore the risk of contaminating sediments is considered relatively low compared to other release regimes (such as mine water releases).
7.2				(new comment) It is unclear in Section 7 what the required discharge volume during construction will be based on the new design option 5. Section 7 only states that there will be a significant reduction in the excess construction water volume. The additional water storage volume under option 5 of 2.5 GL is greater than the previous predicted volume to be discharged during construction of 1.5 GL. It is therefore, unclear why discharge is still required during construction. No justification has been given to why the same conditions that are proposed for the operational phase have been applied to construction. Of note is that the concentration of dissolved zinc, nitrate and total nitrogen is greater in Eldridge Pit than the mix of water to the discharged during operation (9 parts Eldridge to 1 part Wises Pit).	Further detail is required in the last paragraph in Section 7.2.1.2 on page 235 regarding the proposed volume of water to be discharged during construction and the proposed construction conditions.	Annual controlled release statistics for the construction phase are presented in Table E2 (in the Executive Summary) and Table 96. A description as to why conditions for operation phase have been applied to construction is presented in Section 7.2.1.2. Releases are required during construction to dispose of excess water generated by rainfall runoff.
7.2.1.2	Construction Stages and Model Objective Functions	While this section indicates that a release of waters would not be required until Construction Phase 3 (188 days), any proposed construction release should be optimised to take advantage of high river flow scenarios across the three year construction phase.	Please provide clarity on the proposed duration of the construction releases (i.e. first and last date of potential release, integrated with the construction schedule)	It remains unclear in this section what is maximum volume of release required during the construction phase, and the source (Eldridge/Wises/Mix) of any proposed release releases at different times during the construction period.	The maximum volume (worst case scenario) which may be required to be released during construction should be providing, including the source (Eldridge/Wises/Mix) of any proposed release releases at different times during the construction period.	Release volumes will depend on rainfall.
7.3	Water Quality Impact Assessment	Scouring near the temporary outfall is noted. However, the area over which scouring may occur is not adequately described. There is no description of potential impacts to flora and fauna values within the area that may experience scouring. No assessment is provided of potential indirect impacts on downstream environmental values from increased sedimentation and turbidity from scouring.	Describe the area that may experience scouring including any potential direct and indirect impacts to flora and fauna values.	No further comments		

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
7.3.1	Near Field Mixing Zone Assessment	Construction phase discharges of toxic wastewater proposed via pontoon mounted submersible pumps and HDPE pipes is proposed for a significant yet undefined duration of time (>1.5 years?). Water Sciences does not support a large toxicity mixing zone where it is not consistent with the Australian Water Quality Guidelines and has the potential to cause environmental harm. In such cases, a diffuser to promote near-field mixing of the release would normally be required to minimise impacts. No dispersion assessment (CORMIX) is presented in the IAR for the construction discharge proposal (Chapter 7.2 Preliminary Construction Phase Assessment, Section 7.3.1 Near Field Mixing Zone Assessment).	Further consideration and modelling of mixing zones for the proposed construction discharges via the "temporary outfall structure" and via the "diffuser" is required as part of the IAR. Refer to page 13 of the Technical guideline: Wastewater release to Queensland waters for further guidance (https://environment.des.qld.gov.au/assets/documents/regulation/pr-gl-wastewater-to-waters.pdf). Define the physical dimensions of the initial mixing zone where relevant WQOs and DTA thresholds are reached (see further comments in relation to appropriate safety factors and considerations for the application of DTA data) via 1) the "temporary outfall structure" and 2) the "diffuser" (for construction phase proposal).	No new near field mixing zone modelling has been done for the proposed construction phase release. The reason provided for this is that the same release conditions as the operational phase will be used. However, as outlined above, the concentration of dissolved zinc, nitrate and total nitrogen is greater in Eldridge Pit than the mix of water to the discharged during operation (9 parts Eldridge to 1 part Wises Pit). Therefore, the worst case scenario has not been modelled for these parameters. It is also suggested that the outfall structure may not be complete and that initial releases during the construction phase may be via a simple outfall structure. Mixing zone modelling for operation included two different conceptual diffuser configurations. Therefore, as per previous comments, the modelling for the operational phase does not provide the worst case scenario of a simple/temporary outfall structure. Mixing zone impacts of entrained metals in sediments should also be addressed.	Provide mixing zone modelling representing the construction release conditions (source water, maximum release volume, outfall structure).	CORMIX modelling has now been undertaken for construction phase, assuming use of diffuser. Worst case result for operations indicates a maximum distance of 623 m downstream before the WQO for dissolved zinc is met. For construction, this distance is 772 m. Results will be presented with supplementary information. Assumes no releases will be undertaken without a diffuser. Appropriate infrastructure will be in place prior to any releases occur.
7.3.2	Far Field Assessment of Sustainable Load (Mass Balance)	An incomplete impact assessment is presented for the mid-field locations within the Copperfield River. Limited detail is presented regarding the anticipated concentrations of toxicants and duration of likely exposures within the identified semi-permanent pools downstream of the proposed wastewater discharge.	If the majority of release opportunities within the construction phases are utilised in succession (over a wet season for example), what are the predictions regarding aquatic ecosystem impacts within these important refugia.	There is a potential risk of algal blooms within the mixing zone and the semi-permanent pools downstream. With the concentration of total nitrogen in the release water 47 times, nitrate 8 times and total phosphorus 2.5 times the WQO. Efficacy of proposed flushing (ie. cease release at <400ML/d) in downstream water bodies (ie Copperfield Gorge) is inadaquately discussed.		Refer to Section 7.4.2 of IAR.
7.3.4	Assessment of Water Quality Impacts to Environmental Values	The concentrations represented by the mass balance will only be present whilst the release is occurring. However, the section does not provide examples of how long the system takes to returns to < WQOs, how long the water takes to move from Kidston to Einasleigh, etc.	The IAR needs to detail, how long the system takes to returns to < WQOs in scenarios where they are being exceeded for large periods downstream, how long the water takes to move from Kidston to Einasleigh (i.e. days/weeks), how long will elevated concentrations be present at that location; and the proportion of days per year where there is 'unimpacted' water present in the system, compared to release impacted days.	This comment is still valid		Supplementary information will be provided to respond to this comment. It is proposed to use GoldSim to estimate these durations.
7.3.4	Assessment of Water Quality Impacts to Environmental Values	Many indicators are predicted to exceed WQOs up to and over 50 km downstream from proposed construction release. The impact assessment has also assessed the anticipated resultant water quality against less stringent toxicity guidelines due the temporary nature of this discharge (80% species protection). Again, exceedances are modelled to occur downstream up to 50 km. If this is correct, this places this application within a high-risk category in terms of potential aquatic ecosystem and drinking water impacts. Wastewater discharge assessments typically attempt to achieve relevant WQOs within 300m (or 3 stream widths if less) rather than 50 km (page 14 of Technical guideline: Wastewater release to Queensland waters).		This section has been updated based on the design option 5. As outlined above (Section 6.2.3), the concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream. The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus. However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular semi-permanent pools downstream.		A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	Construction releases are predicted to exceed the available assimilative capacity of the receiving environment (Copperfield River) and would	The IAR should provide a comprehensive and detailed quantitative assessment of the project's potential impacts on environmental values.	This section has been updated based on the design option 5. As outlined above (Section 6.2.3), the concentration of total nitrogen will exceed the WQO and the baseline water quality at Einasleigh, 48.3 km downstream. The impact assessment states that it is unlikely that the increased nitrogen concentration would lead to algal bloom, due to the limited availability of phosphorus. However, the concentration of total phosphorus in the pits is also greater than the WQO. There is therefore, a potential risk of algal blooms downstream of the release point, in particular semi-permanent pools downstream.	A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided	A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part
7.3.4	Assessment of Water Quality Impact to Environmental Values	The information provided in Table 92 is not sufficient to support the statement that impacts from construction releases will be transitory and reversible. For example, an exceedance of the WQO for 95% species protection 48km downstream of the release for up to 41 days per year for three years has the potential to significantly impact environmental values - yet potential impacts are discussed in a cursory manner in the IAR.	Further evidence, including a detailed impact assessment based on reasoned discussion should be provided to support the assertion that potential impacts of construction releases will be transitory and reversible.			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	Post-release flushing from the Copperfield Dam is proposed to aid in the dilution of releases from the project site. However, a quantitative assessment of the impact of this flushing on water quality is not provided in the IAR. If post-release flushing from the Copperfield Dam is proposed	The IAR should include a quantitative assessment of the impacts of post-release flushing on water quality to support the implementation of this measure to improve water quality after a water release.			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	The impact assessment does not include a risk matrix assessing the likelihood and severity of potential impacts arising from the proposed operational and construction water releases. The risk matrix should detail how proposed mitigation measures would reduce the likelihood or	Include a risk matrix assessing the likelihood and severity of potential impacts of the proposed project, including the likely effectiveness of mitigation measures in reducing the likelihood or severity of impacts.			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	Based on worst case maximum values during the later stages of construction - WQO for drinking water are predicted to be exceeded at downstream locations at which water may be used for drinking. Given the potential for impacts to human heath, the precautionary approach must be applied so that no water from the Copperfield River is consumed, and potable water provided, at any stage during operations and construction when WQO for drinking water may be exceeded.	Revise this IAR section to clarify that no river water will be used for potable uses at any stage during operations and construction when WQO for drinking water may be exceeded.			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	Water quality should be monitored at the Oaks homestead to validate modelling results and confirm that water quality objectives for potable water are achieved before potable usage of water at this location recommences following a release.	Include the monitoring of water quality at the Oaks homestead and triggers for the cessation and recommencement of the use of water from the Copperfield River for potable uses at this location. Provide details on how the proponent would communicate with the Oaks homestead to ensure river water is not in used during releases when WQO for drinking water may be exceeded. It is recommended that Queensland Health be consulted regarding the appropriateness of this WQO exceedance and any proposed mitigation measure(s).			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.4	Assessment of Water Quality Impact to Environmental Values	Mitigation measures are not proposed to improve the quality and quantity of pit water prior to release - despite the exceedance of WQO during construction releases.	Describe and fully assess suitable mitigation measures to limit WQO exceedances during construction releases, including mitigation measures to improve the quality and reduce the quantity of pit water prior to any release.			A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
7.3.5	Conclusions of Water Quality Impact Assessment	Justification regarding proceeding with 1:25 approach are based on the: 1) DTA biological effects data, and; 2) Temporary nature of the construction phase discharges (3 years) for the proposal being satisfactory in terms of adverse impacts. The water quality of the DTA Composite 2 is a better quality than observed from historical sampling. The following table presents a comparison between the DTA sample and statistical information in terms of historical water quality from Eldridge Pit: Constituent concentration in composite sample submitted for DTA 2 90% Eldridge:10% Wises Corresponding closest percentile from Eldridge Pit historical data in Appendix B (maximum recorded) Dissolved Zinc (1.09 mg/L) 80th percentile (max 1.75 mg/L) Dissolved Cadmium (0.0221 mg/L) 75th percentile (max 0.0321 mg/L) Dissolved Cobalt (0.004 mg/L) 20th percentile (max 0.029 mg/L) Electrical Conductivity (3210 µS/cm)) 75th percentile (max 4790 mg/L) Sulphate (1720 mg/L) 25th percentile (max 2500 mg/L) The above table presents a selection of certain relevant indicators, and is not a comprehensive comparison. It does highlight, however, that the water quality tested for biological impacts (using DTA) was generally better quality than historical worse-case findings. What is clear from much of the information presented in the construction IAR is firstly, that the 1:25 discharge proposal represents a high risk to downstream environmental values and secondly, that water quality in the proposed discharge will change over time and is not static.	If the DTA is proposed to be used as the primary justification of low risk, then the end of pipe limit maximums will need to be set according to the water quality measured within the DTA composite (and adjusted by agreed safety factors for hardness modification and to lowest NOEC (x 10)). The hardness in the lowest DTA dilution is still very high and predictions regarding the toxicity ameliorating effects at this range may be less predictable. According to the ANZECC guidelines where mixture toxicity is observed, the next step in the assessment is toxicity identification and evaluation (TIE) techniques, which assist in identifying the main toxicants of concern for that particular mixture (see page 3.4-16 ANZECC). This could be considered further although is time consuming. The DTA did not actually investigate a dilution factor relevant to the proposed discharge dilution (lowest in the DTA is 6.25%, while the discharge proposal is 4%). This presents more uncertainty with the DTA and a discussion should be presented about whether application of a safety factor on top of the lowest NOEC may be appropriate, i.e. build in a safety factor to lowest NOEC (x 10). Further discussion is required in the IAR regarding the anticipated long term impacts to aquatic ecosystems from potential toxicity experienced intermittently over three years (as per the IAR states). The life-cycles of relevant species should be outlined and three years of possible population impacts discussed, including how this timeframe may negatively influence the possibilities of recovery. Three years is a relatively long duration for impacts without further assessment, especially given species lifecycles may range from 2 years or significantly less. Where a pre-approval risk assessment highlights a potential for high risk from discharges, there is the possibility that post-approval DTAs can be conditioned and utilised for compliance/ongoing risk assessment and feedback into tiered approval conditions. This would involve a suitable frequency and sampling locations for DTA samples collected directly from receiving water during the influence of discharges and should relate back to the dilutions allowed as part of the approval and original assessment. A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided. The proponents mention that there is no evidence of algae growth within Eldridge Pit to date, despite nitrate levels of 5 mg/L. The toxicity assessment revealed that 100% Eldridge water was non-toxic within an algae test, i.e. it did not inhibit growth. Hence an assessment is required regarding other important factors downstream including turbidity and settling which may inhibit or promote algal growth.	This section has been updated based on the design option 5. Therefore, most comments are no longer valid. However, the comment regarding a detailed assessment of the potential for algal blooms is still required. This is relevant for operation and construction releases. A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided. The proponents mention that there is no evidence of algae growth within Eldridge Pit to date, despite nitrate levels of 5 mg/L. The toxicity assessment revealed that 100% Eldridge water was non-toxic within an algae test, i.e. it did not inhibit growth. Hence an assessment is required regarding other important factors downstream including turbidity and settling which may inhibit or promote algal growth.	A more detailed assessment of the proposal in relation to the potential for algae blooms should be provided. The proponents mention that there is no evidence of algae growth within Eldridge Pit to date, despite nitrate levels of 5 mg/L. The toxicity assessment revealed that 100% Eldridge water was non-toxic within an algae test, i.e. it did not inhibit growth. Hence an assessment is required regarding other important factors downstream including turbidity and settling which may inhibit or promote algal growth.	A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information. A draft response addressing the risk of algal blooms has been prepared to facilitate discussions (refer to AECOM memo dated 6 February). This text will be updated as part of the supplementary information.
7.3.5	Conclusion of Water Quality Impact Assessment	The assumption that the river will not be used for recreation in high flow conditions is not an acceptable measure to avoid the impacts of the exceedance of recreation WQO for Manganese.	Explore and fully describe suitable additional mitigation measures to further limit the exceedance of WQO.			Revised assessment for temporary construction releases indicates that there will be no exceedances of the WQO for manganese.
7.5.1	Water Quality	The sensitivity of macroinvertebrates downstream from the release location is stated in this section, including the "adoption and application of appropriate release management strategies" to reduce the level of residual risk to aquatic downstream aquatic values. These potential management strategies and mitigation measures not detailed in the IAR, nor is their potential efficacy adequately assessed. Monitoring outlined in Table 5 of the REMP is not of a sufficient frequency to enable the effective management of water releases to limit impacts to flora and fauna values.	The IAR should provide detailed management and mitigation measures to further reduce the risk of construction water release impacts to aquatic flora and fauna values. The IAR should adequately assess and provide evidence of the likely efficacy of any proposed mitigation measures.	No further comments		
7.5.1	Water Quality	The IAR suggests macroinvertebrate communities as an ideal biological indicator for the future project REMP. However, no detail is provided as to how macroinvertebrate sensitivities would be used to monitor potential impacts of the proposed project, or how the proposed project may be modified if impacts to macroinvertebrates are detected. Note - frequent monitoring would be require to ensure any impacts are detected and can be responded to within a timeframe likely to limit those impacts.	The IAR should detail how macroinvertebrate monitoring would be undertaken to enable project modification in response to the detection of impacts on macroinvertebrates. The proponent should consider increasing the frequency of sampling of flora and fauna values to allow modification of releases in response to any monitoring results.	No further comments		
7.5.2	Hydrology	Noting that changes in hydrology and increased flows and water permanency may suit some species, it is also likely to negatively impacts other species. This should be assessed the IAR.	The IAR should detail and discuss which species are likely to benefit or suffer under a regime with increased water flow rates and increased water permanency.	No further comments		
7.5.3	Erosion and Sedimentation	This section does not adequately describe the impact/potential impact regarding the accumulation of contaminants in sediment.	The IAR needs to further assess the actual/potential impacts that accumulation of sediment will have on the receiving environment that provides scientific justification that these impacts are 'low'.	No further comments		

		DES Comments on IAR first submission		DES comments on IAR second submission		
IAR Section	Heading / Topic	Review Comment	Recommendation	Review Comment	Recommendation	AECOM Comments
9.1	Summary of Proposed Release Criteria	Release conditions should include contaminant end of pipe triggers and limits for the relevant parameters, in addition to conditions regarding flow triggers and minimum dilutions. The impact assessment has been undertaken on the basis of assessing the risk of 1:25 or 1:200 assuming water quality from historical information (and based on the site water balance predictions of what will be required in terms of discharges). Licensing processes utilise information from the impact assessment to then consider the appropriate conditions, EOP and within the receiving environment. Assumptions cannot be reliably made to assert that water quality within the pit will not alter (or deteriorate) over the operation lifetime. This is especially important, given the likely increased ingress of groundwater once the current water levels in Eldridge Pit are dropped. There is also an identified potential for oxidisation of the sulphides and liberation of cadmium, zinc, copper and arsenic from pit walls.	If the maximum release rate is proposed to be adjusted on real time data from upstream gauge, then the minimum flow triggers should also be managed on a real time or short term basis (i.e. cubic metres/second, rather than ML/Day). Any request to use variable release ratios (volumes) based on real time dilution factor with the receiving water flows presents additional complications in regards to the onsite management and compliance assessment. A discussion of how the onsite management would be designed to enable rapid alterations of discharge volumes to fluctuating natural stream flows should be detailed within the IAR. Some early attempts to develop an EOP limits appear to have been presented for dissolved zinc for operational discharges, but nothing has been presented for the construction phase limits. If modelling has assessed EOP maximum of 1.58-1.75 for dissolved zinc then this will more closely reflect the EOP limit, which should then be applied. Doubling the end of pipe limit would require impact assessments and modelling using the requested limit, and this has not been undertaken. The release ratio during the construction phase of 4.2% listed in Table 108 does not equate to 25:1. The release ratio should read 4%. This error needs to be corrected throughout the documents.	The previous comments are still valid, except those related to the 1:25 dilution for construction.		To be discussed. EOP limits to be established at a later date.
9.2	Monitoring	Increased water quality and aquatic ecosystem health risks from construction phase proposal would require, if approved, a more comprehensive and responsive monitoring regime. Within the "Overview of Receiving Environment Monitoring Program" Table 109, the upstream and downstream water quality monitoring frequency during releases stipulates a sample is to be taken within the first 24 hours, and then every three days thereafter until one week after the release ceases. Given that Type 1 discharges will not occur at flows less than 400 ML/day, an estimate of how long the minimum flow (plus discharge volume for construction phase 16 ML/day) would take to reach the last downstream monitoring site EG1 is necessary. The proposed monitoring timing/frequency should capture sampling for declining water quality and impacts in relation to the predicted timing of impacts.	The approval will need to nominate the relevant indicators, conditions and monitoring points/frequency. Currently this information sits within the REMP document. The nominated site DS1 is listed as immediately downstream of the mixing zone, however, no clarification of which mixing zone is relevant for this site location has been presented. Further downstream, monitoring is also required with the semi-permanent waterholes Pond 4, Pond 5, and W3 during the construction phase.	The previous comments are still valid. Pond 4 and the Einasleigh gorge downstream have been removed from the monitoring program in the new IAR. Copperfield gorge has been added, is this site equivalent to the Einasleigh gorge site? Potentially groundwater quality monitoring should be included in the monitoring program.		Pond 4 has been removed as monitoring will occur at Pond 5. These ponds are so close together that in wet periods it is likely that they will be the one contiguous pond. Monitoring at Einasleigh Gorge was not removed. There was a name change to Copperfield Gorge - this was done in error and still represents the same location. Groundwater monitoring was included in the REMP. Refer to the bottom two lines of the table in Appendix A of the REMP
Appendix B	Water Quality Statistics Table	Appendix B appears to exclude the information more recently obtained from depth profiling within the Eldridge Pit.		The previous comments are still valid		August 2018 pit profiling results are discussed at the end of Appendix C (Pit Profiling)
Appendix G	DTA - June 2018	The most diluted wastewater Rainbow fish embryo hatching assessment (for both DTA 1and DTA 2) shows a trend (although not statistically significant) of more toxicity and much higher variability than less diluted tests. The possible influence of hardness within the DTA dilutions is lacking from the IAR. A written discussion and explanation from Ecotox Pty Ltd in regards to the possibility of a multiple phase dose response should be included in the IAR. The possibility of higher toxicity in more dilute mixtures should be addressed given the well-established influence of water hardness on toxicity. Can the results of the DTA be relied upon to assure that no acute and/or chronic toxicity impacts are posed by the proposal (over a 3 year period of repeated event-based discharges)?		The previous comments are still valid		Numerous opportunities were provided for comments on the DTA, from early 2018 onwards. Unless critical to the assessment of the IAR we would prefer not to have to go back over work which has been submitted for review numerous times already.
Draft REMP						
1.0	Aims and objectives	Note - An objective of the REMP is also to outline mitigation and measurement measures that would be implemented to further limit potential impacts of the water releases, as suggested in section 7.5.1.	The IAR should include potential mitigation and management measures that may be implemented in response to monitoring undertaken as part of the REMP to limit impacts of water releases. It should include triggers for the implementation of each mitigation measure.	The previous comments are still valid		Adaptive mitigation measures are included within the IAR - Section 9.3. The REMP outlines the monitoring regime to be applied through the construction and operation phases of the project. Should unacceptable exceedances be found to occur as a result of the Project releases then the proposed mitigation measures will be implemented accordingly to reduce these impacts to acceptable levels.
4.1	Figure 3, Water monitoring location map	Figure 3 is not included in the draft REMP.	Include Figure 3 to clarify proposed water quality monitoring locations.	The previous comments are still valid		See figure 75.
4.4.2	Assessment Method	The methodology for assessing aquatic flora and fauna communities is not provided.	Detail the methodology for assessing aquatic flora and fauna communities.	The previous comments are still valid		See section 4.3.
6.0	Reporting	The placeholder in this section indicates that reporting will be completed "as per conditions of EA." Note - the proposed project will not have an EA as it is not an environmentally relevant activity requiring an EA.	Clearly state here and in other sections of the IAR that no EA approval would be issued for the proposed project as the activity is not an ERA. Any approval conditions would sit as imposed conditions in the Coordinator-General's Evaluation Report for the proposed project. Compliance with any imposed conditions would be the responsibility of the Office of the Coordinator-General.	The previous comments are still valid		To be updated to read, as per the conditions of approval.

Appendix B

Nutrient and Algal Bloom Assessment

Appendix B Nutrient and Algal Bloom Assessment

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To:
Arran McGhie
Chief Operations Officer
Genex Power

Project name:
K2H IAR

Project ref:
60544566

From:
Nicky Lee

Date:
February 28, 2019

Memo

Subject: Response to DES Comments on Algal Bloom Risk

On 31st January 2019, the Queensland Government Department of Environment and Science (DES) provided comments on the final version of the Kidston Pumped Storage Hydro Project Impact Assessment Report (dated 11th January 2019). This memorandum outlines a draft response to comments related to the risk of algal blooms in the receiving environment associated with releases from the Project.

Assessment of Nutrient Concentrations

- The Copperfield River receiving environment contains elevated baseline concentrations of nitrogen. Historical data as well as the results of the intensive water quality sampling program undertaken in February 2019 (refer to Section 3 of this Supplementary Information) indicates that baseline total nitrogen is above the default WQO in all receiving environment samples (W1, W2, W3, Sandy Creek, all semi-permanent pools and Einasleigh Gorge). Similar concentrations are observed at DNRME Gauge 917106A Einasleigh River at Einasleigh (a median concentration of 0.23 mg/L, which is above the default WQO of 0.15 mg/L). This data suggests that the default WQO (which is based on ANZECC/ARMCANZ 2000 default WQOs for upland rivers in Tropical Australia) may not be reflective of baseline conditions in the Gilbert Basin receiving environment. As stated in the Queensland Water Quality Guidelines "*There are no QWQG for the Gulf Rivers. Users may default to the ANZECC 2000 Guidelines, although these are unlikely to be appropriate, particularly for intermittent and ephemeral inland streams. Users are strongly encouraged to collect local data and develop local guidelines*."
- Nitrate as N contributes towards the total nitrogen value. The default WQO for nitrate is 0.7 mg/L, whilst the total nitrogen WQO is 0.15 mg/L. It is counter-intuitive that the nitrate WQO is higher than the total nitrogen WQO, as nitrate will contribute towards some percentage of the total nitrogen value. Therefore the total nitrogen WQO of 0.15 mg/L is considered to be unrealistic or inappropriate for the Copperfield River receiving environment.
- Furthermore there is substantial data from DNRME gauges throughout the catchment on nitrate values (but not total nitrogen). The long term monitoring data from these other DNRME gauges (upstream and downstream) throughout the catchment show that nitrate values (which contribute to total nitrogen) are all elevated above the default total nitrogen WQO (refer Table 9 for further information). Therefore total nitrogen values will be well elevated over the default WQO throughout the catchment as well.

- If there were no other forms of nitrogen in the catchment (i.e. nitrate was the only form of nitrogen contributing towards total nitrogen), all values from the DNRME gauges would exceed the total nitrogen WQO of 0.15 mg/L (Table 9). In addition, the Spanner Waterhole, Kidston Headwater and Kidston Tailwater gauges (all upstream of the K2H Project) exceed the nitrate WQO of 0.7 mg/L. Therefore this adds further evidence that the default WQO for nitrate, as well as for total nitrogen, are not suitable and are in fact invalid for the Copperfield River catchment.
- Whilst maximum concentrations of nitrate, total nitrogen and total phosphorus in release waters are above the default WQO, the final mixed concentrations in the receiving environment post-release are all well below the WQO with the exception of total nitrogen, the baseline concentration of which is already above the WQO (see Table 10 and Section 3 of this Supplementary Information**Error! Reference source not found.**) which in any case, as outlined above, is unrealistic or invalid for the Copperfield catchment.
- Phosphorus is often the limiting nutrient preventing rapid growth of many microorganisms. The ratio of Total Nitrogen to Total Phosphorus is above 16 in the receiving environment pre and post release, as well as in the Eldridge Pit (refer to **Error! Reference source not found.**), therefore these waterbodies are considered to be phosphorus deficient (ANZECC/ARMCANZ 2000). If all other conditions are ideal for microbial growth and phosphorus is the limiting nutrient, increased concentrations of phosphorus in water (>0.05 mg/L) could lead to enhanced algal growth (ANZECC/ARMCANZ 2000). Mass balance assessment has indicated that concentrations of phosphorus will only increase above baseline by up to approximately 0.0002 mg/L; this very small value is well below the threshold identified in ANZECC/ARMCANZ 2000 and within the likely margin of error of the various methods used in the assessment and by the laboratory. Although phosphorus is the limiting nutrient post-release (as evidenced by the high total nitrogen to total phosphorus ratio post-release), this very minor increase in phosphorus concentrations is highly unlikely to result in an algal bloom. There is a maximum modelled increase in total nitrogen concentrations of 0.035 mg/L above baseline. The increases in nitrogen and phosphorus are very minor, especially when compared to the concentrations of total nitrogen and total phosphorous released into other freshwater systems. Furthermore, these concentrations will exist only for a short period (i.e. during a release only).
- The dominant land use in the Copperfield River catchment is low density cattle grazing. Baseline phosphorus concentrations at W2 indicate that there are no significant phosphorus sources in the vicinity of the Project.
- The maximum predicted concentration of total nitrogen in the Copperfield River post-release (~0.285 mg/L) is well within the limits previously observed in the receiving environment (maximum value of 0.91 mg/L), especially considering the additional data from DNRME gauges outlined in Table 9 (assuming nitrate is analogous to total nitrogen). The Project will only marginally increase nitrogen values in the receiving environment from 0.25 mg/L to a maximum worst case of 0.285 mg/L; this is an increase of 14% above the existing condition. In the 95 %percentile scenario, with a value of 0.256 mg/L in the receiving environment, this represents an increase of only 2.4%. Compared to other industries, such as WWTPs, this is a negligible increase in the concentration of nitrogen in the receiving environment. An increase of nitrogen in the receiving environment of 2.4% will **not** increase the risk of algal blooms as it is not a substantial increase, and is well within the limits of nitrogen (and nitrate) experienced in the receiving environment from long-term DNRME data.
- The maximum predicted concentration of total phosphorus in the Copperfield River post-release (~0.0052 mg/L) is well within the limits previously observed in the receiving environment (maximum value of 0.08 mg/L).

Risk of Algal Blooms in Copperfield River

- There has been no observed or anecdotal evidence of algal blooms in either the pits or receiving environment, despite the relatively minor elevated concentrations of nutrients or elevated background nitrogen levels in the receiving environment.
- Given that elevated concentrations of both nitrogen and phosphorus have been observed in both the pits and receiving environment without evidence of algal blooms, this suggests that blooms resulting from releases are extremely unlikely.

- Furthermore, releases will only occur during periods of high flow, which are generally not conducive to algal blooms (lakes, ponds and slow-moving rivers are more susceptible to algal blooms).
- Risk of algal blooms in not only the mixing zone, but also downstream pools/waterholes and the Einasleigh Gorge is minimised by ensuring that post-release flushing of extended duration (median post-release flush duration of between 29 and 32 days) and volume (median post-release flush volume of between 1,676 and 1,758 ML) occurs following each release event (refer to Table 11). Releases are temporary in nature, with an anticipated median duration of between 7.0 and 7.7 days per event (refer to Table 11).
- Ongoing monitoring of nutrients and total algal count will be undertaken in the receiving environment (including downstream pools and the Einasleigh Gorge) and pits as part of the REMP. A number of strategies have been identified to provide further mitigation if required (e.g. extending flushing and ceasing releases during the dry season). These strategies are adaptive in their nature and can be applied if found to be necessary based on feedback from the downstream monitoring programme outlined in the REMP.

Summary

In summary, the Project has been designed to minimise impacts to the environment and follows a risk-based assessment approach, ensuring that some assimilative capacity is preserved. Based on the points outlined above, the risk of algal blooms in the receiving environment (including semi-permanent pools downstream of the release and the Einasleigh Gorge) associated with releases from the Project is considered to be negligible.

Table 9 Nitrate as N concentrations from DNRME gauges in the Gilbert Basin

Gauge	Median (50th percentile) Nitrate as N Concentration (mg/L)
Spanner Waterhole	0.75
Kidston Headwater	3.2
Kidston Tailwater	1
Middle_Ck Gap	0.9
Possum Pad	0.95
Gilbert_T Gilberton	1.4
Narrawa 2	0.55

Values in red indicate an exceedance of the default WQO for nitrate (0.7 mg/L)

Table 10 Nutrient Concentration Summary

Parameter	Default WQO (mg/L)	Receiving Environment (W2) 50th percentile (mg/L)*	Max. Release Concentration for Construction (mg/L)*	Max. Estimated Final Receiving Environment Conc. (mg/L)
Ammonia as N	0.5	0.02	0.211	0.0211
Nitrite as N	1.0	0.005	0.005	0.005
Nitrate as N	0.7	0.033	**5.45**	0.0598
Total Nitrogen as N	0.15	**0.25**	**7.0**	**0.2850** (P95 of **0.256**)
Total Phosphorus as P	0.01	0.005	**0.0315**	0.0052
TN:TP Ratio	N/A	50:1	222:1	55:1

*Based on limited data points (three or less). Additional baseline data to be collected.
Values in red indicate an exceedance of the default WQO.

Table 11 Release Statistics

Parameter	Temporary Construction Releases	Operational Releases
Median volume released per event	101 ML	68 ML
Median number of release events	4.4 events/year	4.0 events/year
Median duration of release	7.7 days/event	7.0 days/event
Median post release flush duration	29 days	32 days
Median post release flush volume	1,676 ML	1,758 ML
Approx. ratio of release to flush volume	1:17	1:26

Appendix C

Revised REMP

C

Integrated Assessment Report
Genex Power Ltd
27-Feb-2019

DRAFT

Kidston Pumped Storage Hydro Project

Receiving Environment Monitoring Program

DRAFT

Kidston Pumped Storage Hydro Project

Receiving Environment Monitoring Program

Client: Genex Power Ltd

ABN: 18 152 098 854

Prepared by

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Quality Information

Document	Kidston Pumped Storage Hydro Project
Ref	60544566
Date	27-Feb-2019
Prepared by	Reece Fraser & Nicky Lee
Reviewed by	James Tuff

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	31-Aug-2018	For Client Review		
1	10-Jan-2019	Revised following OCG Comments - Issued for Client Review		
2	26-Feb-2019	Revised following OCG Comments - Issued as FINAL		

Table of Contents

Appendix A
REMP Monitoring Locations and Frequencies

A

1.0 Aims and Objectives

Genex Power Ltd (Genex) commissioned AECOM Australia Pty Ltd (AECOM) to prepare this Receiving Environment Monitoring Program (REMP) for the Kidston Pumped Storage Hydro Project (the Project), which proposes to develop the former Kidston Gold Mine pit voids to store water and use it to generate a form of gravitationally-driven hydroelectric power. The main objective of the REMP is to report against relevant water quality objectives (WQOs) for receiving waters potentially affected by controlled releases of pit water and to verify water quality assumptions presented in the Impact Assessment Report (IAR) for the Project (AECOM 2018).

Insert reference to relevant conditions of approval when available.

This document has been prepared in accordance with the requirements of the Queensland Government Department of Environment and Science (DES, formerly DEHP) technical guideline entitled '*Wastewater release to Queensland waters*' (ESR/2015/1654, Version 2, September 2015) and the '*Receiving environment monitoring program guideline*' (ESR/2016/2399, Version 2.01, June 2015) .

2.0 Activity Description

2.1 Project Overview

The Project involves storing water within an elevated upper reservoir, allowing energy to be stored in the form of gravitational potential energy. During periods of peak electrical demand, the water will be released from the upper reservoir into a lower reservoir via a turbine-generator system that produces electricity. At the end of the electricity-generating cycle, the turbines will be reversed and, powered by electricity from the nearby Kidston Solar Farm, will be used to pump the water from the lower reservoir back to the upper reservoir to begin the electricity generation cycle again. The Project proposes to utilise two existing mining pits, Wises (upper reservoir) and Eldridge (lower reservoir), at the decommissioned Kidston Gold Mine. The Wises Pit will be modified via the construction of a perimeter dam to increase its storage volume.

The Project generation capability is 250 MW with a storage capacity of 1,870 MWh. The Project forms a component of the wider Kidston Renewable Energy Hub. Once completed, the Project will be the first in the world to utilise two disused mine pits for hydroelectric power generation, and the first hybrid large-scale solar photovoltaic and pumped hydro storage plant.

A major component of the Project is the ability to control the stored water, both in the initial phase of construction of site infrastructure (e.g., the power generating facilities, access tunnels etc.), and during operations, when water will be transferred from the upper reservoir (the Wises Pit) to the lower reservoir (the Eldridge Pit). Crucial to this control will be the potential to release additional volumes of water that may arise following periods of high water ingress, such as wet season rainfall events and storms. Water release may be required to maintain operations during power generation.

2.2 Water Releases

As described above, the Project may need to release water in order to maintain reservoir levels during the power generation cycle, to prevent inundation of key infrastructure, and/or to mitigate possible water quality deterioration. It is proposed that water will be released from the Project via one of two different strategies depending on the nature of the causal event. These two release strategies are described as follows:

2.2.1 Event-Based Discharge of Water to Maintain Water Levels and Quality

Additional water added to the reservoirs through rainfall/runoff ingress during either critical construction stages or normal operations may, at times need to be released. The preferred method is via the controlled release of Project water during periods of naturally-occurring streamflow in the Copperfield River (herein referred to as an event-release). This type of release has a number of advantages, including:

- Releases are conducted within a set of licenced conditions and under pre-determined operating rules to ensure potential impacts are appropriately mitigated.
- Releases are independent of the normal operation of the Project (e.g., the power generation and pump-back phases).

By limiting event-releases to periods of medium to high flow and appropriately managing the release, relevant environmental values (EVs) will be protected.

2.2.2 Pass-Through Discharge

In the event of the forecast of a significant rainfall event (e.g. cyclonic or regional monsoonal trough[1]), Project operations may opt to conduct a pass-through discharge of event-induced incident rainfall, either during specific phases of construction, or during normal operations. This would be achieved by maintaining the upper reservoir at spillway elevation such that any incident rainfall would simply pass through the reservoir and discharge to the Copperfield River via the spillway chute. Depending on the

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[1] The Australian BOM estimates that ~ 4.7 cyclones per year affect the Queensland Tropical Cyclone Warning Centre Area of Responsibility (http://www.bom.gov.au/cyclone/about/eastern.shtml)

duration and timing of the event, the power generation cycle may be required to cease in order to hold the upper reservoir at the required level.

This type of release is not the preferred approach to release water from the Project because:

- Total or partial cessation of power generation may be required.
- The rate of water released would be dependent on rainfall intensity and any attenuation provided by the upper reservoir.
- The water quality discharged during the event would be a function of the extent to which the fresh rainwater mixes with the existing upper reservoir water body.

It is noted however that during a pass-through discharge, Genex would still retain the ability to cease the release by lowering the level of water in the upper reservoir and allowing water to flow back into the lower reservoir.

For both types of releases the protection of EVs will be determined by assessment against:

- Any relevant local water quality objectives (WQOs).
- ANZECC/ARMCANZ 2000 (Australian and New Zealand Environment Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*
- The Environmental Protection (Water) Policy 2009, and the National Water Quality management strategy.
- The hydrological characteristics of the receiving environment (e.g. flows regime, riparian structure etc.).

The Project layout including the release location is shown on Figure 1.

AECOM
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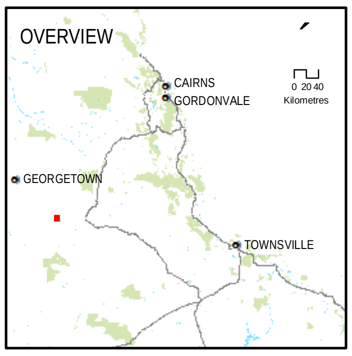
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator

0 100 200 300 400
Meters
1:17,000 (when printed at A3)

Legend
- ● Boundary Points
- Watercourses
- Major Roads
- Minor Roads
- Water Intake Pipeline
- 🟨 Key Project Infrastructure Footprint
- ▨ Spillway Options Corridor
- 🟥 Mining Lease Boundary
- ☐ Cadastral Parcel



Data sources:
Roads and Tracks, Cadastre, Watercourses - DNRM 2017
Electrical Network - Ergon Energy 2017
SISP Imagery 2017

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Kidston Solar Farm
Genex Power Limited

Indicative Project Area

PROJECT ID 60544566
CREATED BY JR
LAST MODIFIED LB - 13/06/2018
VERSION: 1

Figure
1

3.0 Receiving Environment Description

The Copperfield River is a large ephemeral, braided watercourse which runs through the Einasleigh Uplands bioregion in Far North Queensland, approximately 250km southwest of Cairns North. It is situated within the Gilbert River basin, draining towards the Gulf of Carpentaria. The Copperfield River forms the eastern boundary to the site, and is the receiving water body for pit water releases associated with the Project. There are various downstream inflows, including East Creek, Charles Creek, Oak River, Soda Creek and Chinaman Creek. The Copperfield River discharges to the Einasleigh River approximately 50 km downstream of the release location (Figure 1).

During the dry season the Copperfield River typically becomes a series of disconnected pools with reduced water quality. These pools experience large diurnal fluctuations which limit the diversity of remnant flora and fauna communities. The pools can be heavily impacted by cattle and feral pigs as they become the final refuges for these exotic species to water.

The high flow rates experienced in the Copperfield River over the wet season limits the establishment of aquatic flora and small bodied fauna communities. Successful recruitment in these systems can then occur once peak flows have subsided.

The Project area and surrounds consist predominately of agricultural land and are primarily used for grazing (AECOM Australia, 21 December 2017). The Project site, comprising of relatively flat terrain, adjoins lease land to the west and north and is bordered by the Gilberton Road to the south and east.

3.1 Ecosystem Condition Classification

3.1.1 Water Type

The ANZECC (2000) guidelines separate upland and lowland freshwaters at an elevation of 150m AHD. The guidelines also define upland freshwaters as small (first or second order) streams that are moderate to fast flowing as a result of steep gradients and which have cobble, gravel or sand beds. Lowland streams are defined as larger streams (greater than 3rd order) that meander with generally slower flows and beds comprised of sand, silt and mud. The Copperfield River falls into both of these classifications as it is above an elevation of 150m AHD but is a large 5th order stream with a bed of sand, silt, rock and mud. For the purposes of this REMP the Copperfield River in the vicinity of the project has been classified as upland freshwater.

3.1.2 Management Intent

Generally the condition of aquatic ecosystems in the vicinity of the proposed release falls within the category of “Slightly to Moderately Disturbed” as outlined in the ANZECC (2000) and QWQG (2009). However the EPP Water (2009) allows for the separation of slightly disturbed waters from moderately disturbed waters. As presented in the IAR, the macroinvertebrate data for the Project supports the distinction of a ‘Slightly Disturbed’ aquatic ecosystem condition. The definition of slightly disturbed waters is “*waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators – the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water*”.

The management intent of slightly disturbed waters is to gradually improve water quality and to aim to achieve a HEV waterway classification, however it is noted that HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality, including:

- Large-scale historical clearing;
- Cattle grazing and direct access to the river by cattle; and
- Flow regulation by the Copperfield Dam.

3.2 Environmental Values

EVs are qualities designed to provide requirements to make water suitable for supporting aquatic ecosystems and human uses. They require protection from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. The EVs of waters are protected under EPP Water. The policy sets WQOs, which are physical and chemical measures of the water (i.e. pH, nutrients, salinity etc.) to achieve the EVs set for a particular waterway or water body. EVs define the suitable uses of the water (i.e. aquatic ecosystems, human consumption, industrial use etc.).

An evaluation of site specific EVs that are relevant to the proposed release regime and the local receiving environment is provided in Table 1 and is based on the mapping exercise undertaken as part of the IAR.

Table 1 Surface Water Environmental Values Relevant to the Project Site

Environmental Value	Relevance to Copperfield River	Justification
Aquatic ecosystems (incorporating Habitat value)	✓	The macroinvertebrate field survey and desktop assessment supports the definition of a 'Slightly Disturbed' aquatic ecosystem condition (waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators) as discussed in Section 3.1.2
Irrigation (Short Term < 20 years)	✓	There are no known irrigation operations within the receiving environment. There are no current water allocations. However there is the potential for irrigation subject to economic feasibility (Petheram, Watson, & Stone, 2013). Therefore this EV is considered relevant.
Irrigation (Long Term ~100 years)	✓	There are no known established irrigation operations within the receiving environment, and there are no current water allocations. However, following an assessment of the feasibility of irrigation occurring in the catchment, economic factors were found to be the main limiting factor. These may change within the next 100 years, and may allow irrigation projects within the receiving environment, sourcing water from the Copperfield Dam, to become feasible. Subsequently this environmental value has been applied.
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	✓	There are no intensive farm uses within the downstream receiving environment, and there are no water allocations within the receiving environment. There are a number of farm dams that *could* obtain water via unlicensed extraction from the Copperfield River. Therefore this EV is considered applicable.
Stock watering (e.g. grazing cattle)	✓	The majority of the land use in the downstream receiving environment comprises cattle grazing. Cattle are able to directly access the river upstream and downstream of the proposed release location.

Environmental Value	Relevance to Copperfield River	Justification
Aquaculture	✓	Whilst this EV has been assessed and is potentially relevant to the larger catchment, it is not considered to be relevant to the receiving environment immediately downstream. The ephemeral nature of the Copperfield River catchment means that future use for aquaculture is highly unlikely.
Human consumption (e.g. of wild or stocked fish)	✓	As outlined in the site specific assessment contained in the IAR, there are a number of locations where the Copperfield River could be accessed.
Primary recreation (fully immersed in water e.g. swimming)	✓	As outlined in the site specific assessment contained in the IAR, there are a number of locations where the Copperfield River could be accessed. The most likely location for primary and secondary recreation is at the Einasleigh Gorge, approximately 44km downstream. Although outside the expected area of impact, this EV has been nominated as applicable to the receiving environment.
Secondary recreation (possibly splashed with water, e.g. sailing)	✓	
Visual appreciation (no contact with water, e.g. picnics)	✓	Visual appreciation is applicable downstream at Einasleigh in the Einasleigh Gorge. It could be applicable at possible access points.
Drinking water (raw water supplies taken for drinking)	✓	The closest location that could potentially extract water from the Copperfield River for potable supply is at the Oaks Homestead, 11.2km downstream from the proposed release point; however this has not been confirmed. There is no municipal water supply to Einasleigh township. Personal communications with Etheridge Shire Council on 16 May 2018 indicated that there are a number of unlicensed spears into the river in the vicinity of Einasleigh township; it is assumed that these could be used for domestic supply.
Industrial use (e.g. power generation, manufacturing, road maintenance)	✓	The only industrial user of water in the receiving environment is the Project and its co-located solar projects. There is a potential for industrial use in the Einasleigh township.
Cultural and spiritual values	✓	There are a large number of indigenous artefacts identified in the Copperfield River catchment. The Copperfield and Einasleigh Rivers were focuses of indigenous occupation of the area.

The EV for Aquaculture refers to commercial aquaculture operations that produce a multitude of aquatic species for human consumption. Currently there are no such ventures in the receiving environment for the operation, and the potential for such a venture is extremely low. Therefore parameters for Aquaculture will not be considered for the development of WQOs for the Project.

The ANZECC (2000) guidelines do not provide quantitative measures to protect cultural or spiritual values. Consideration is given to cultural and spiritual values of a watercourse by the development of site specific guideline values as recommended for aquatic ecosystem protection.

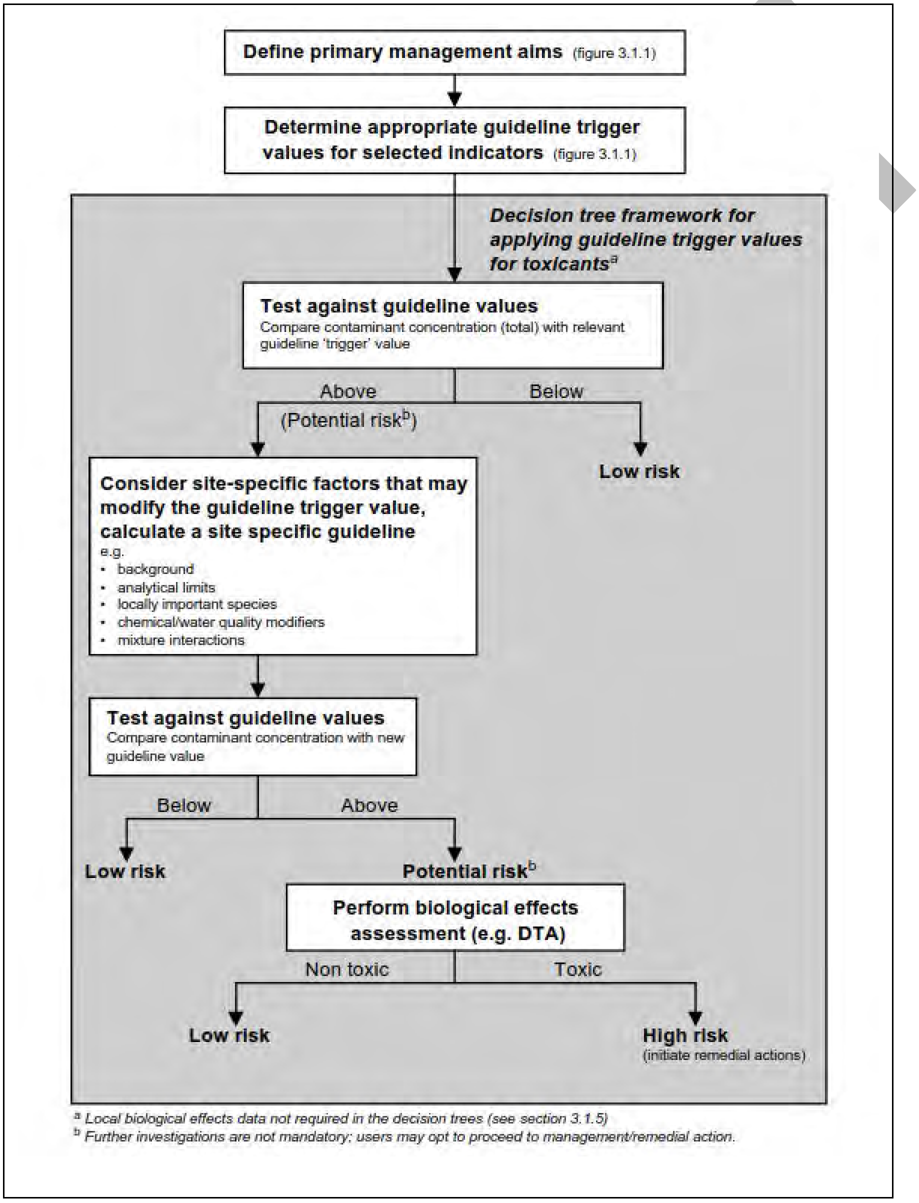
3.3 Guideline Values

3.3.1 Default Water Quality Objectives

The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. As outlined above, the WQOs for Aquaculture (specifically referring to commercial aquaculture operations) have not been incorporated into the assessment of the lowest WQO from all EVs.

The simplified decision tree for assessing toxicants in ambient waters from the ANZECC (2000) guidelines was applied to select and refine WQO's for the Project. Figure 2 describes application of the decision tree.

Appropriate guidelines and trigger values (WQOs) were assembled for the applicable EVs that are outlined in Table 1. The default WQOs for the Project are provided below in Table 2.



[a] *Local biological effects data not required in the decision trees (see section 3.1.5)*
[b] *Further investigations are not mandatory; users may opt to proceed to management/remedial action.*

Figure 2 Simplified decision tree for assessing toxicants in ambient waters (from ANZECC (2000))

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Table 2 WQOs adopted for the project

Parameter	Unit	LOR	Applicable WQO
pH value	pH unit	0.01	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	1	500
Sulfate as SO_4^{2-}	mg/L	1	250
Aluminium (total)	mg/L	0.01	1.52*
Aluminium (dissolved)	mg/L	0.01	0.57*
Arsenic (total)	mg/L	0.001	0.01
Arsenic (dissolved)	mg/L	0.001	0.013
Cadmium (total)	mg/L	0.0001	0.002
Cadmium (dissolved)	mg/L	0.0001	0.0003*
Cobalt (total)	mg/L	0.001	0.05
Cobalt (dissolved)	mg/L	0.001	0.0028
Chromium (total)	mg/L	0.001	0.05
Chromium (dissolved)	mg/L	0.001	0.0017*
Copper (total)	mg/L	0.001	0.2
Copper (dissolved)	mg/L	0.001	0.003*
Manganese (total)	mg/L	0.001	0.1
Manganese (dissolved)	mg/L	0.001	1.9
Molybdenum (total)	mg/L	0.001	0.01
Nickel (total)	mg/L	0.001	0.02
Nickel (dissolved)	mg/L	0.001	0.019*
Lead (total)	mg/L	0.001	0.01
Lead (dissolved)	mg/L	0.001	0.0075*
Zinc (total)	mg/L	0.005	2*
Zinc (dissolved)	mg/L	0.005	0.014
Total Cyanide	mg/L	0.004	0.08
Iron (total)	mg/L	0.05	0.43*
Iron (dissolved)	mg/L	0.05	0.3
Chloride	mg/L	1	175*
Sodium	mg/L	1	115
Boron (total)	mg/L	0.05	0.5
Boron (dissolved)	mg/L	0.05	0.37
Barium (total)	mg/L	0.001	1.0
Beryllium (total)	mg/L	0.001	0.06
Beryllium (dissolved)	mg/L	0.001	0.00013
Mercury (total)	mg/L	0.00004	0.001
Mercury (dissolved)	mg/L	0.00004	0.00005

D R A F T

Parameter	Unit	LOR	Applicable WQO
Selenium (total)	mg/L	0.01	0.01
Selenium (dissolved)	mg/L	0.01	0.011
Uranium (total)	mg/L	0.001	0.01
Uranium (dissolved)	mg/L	0.001	0.0005
Vanadium (total)	mg/L	0.01	0.1
Vanadium (dissolved)	mg/L	0.01	0.006
Fluoride	mg/L	0.1	1
Ammonia as N	mg/L	0.005	0.5
Nitrate as N	mg/L	0.002	0.7
Nitrite as N	mg/L	0.002	1
Total N	mg/L	0.01	0.15
Total P	mg/L	0.005	0.01

[#] Low reliability trigger for 95% species protection as outlined in Volume 2 of ANZECC (2000)

* derived from a TDS concentration for cattle drinking water by using a conversion of EC to TDS = EC x 0.64

[1] Sourced from ANZECC (2000) Aquatic Ecosystem Guidelines for Upland & Lowland Rivers for Tropical Australia – Table 3.3.4

[2] Sourced from Table G.1 of the Queensland Water Quality Guidelines for the Gulf Rivers region (75th percentile value)

[3] A cyanide value of 0.007mg/L (as un-ionised hydrogen-cyanide) is recommended by the ANZECC (2000) guidelines. However the Leading Practice Sustainable Development Program for the Mining Industry publication on Cyanide Management (2008) states:

"Measurement of total cyanide values below 0.1 mg/L and Weak Acid Dissociable (WAD) cyanide below 0.05 mg/L present in mining related discharges may be unreliable and should be reported as 'less than' and not used for compliance purposes… The possible reasons for reporting measured levels of cyanide in surface waters or treated effluent needs to be taken into account when interpreting results of a monitoring program. The first is analytical error; the second is naturally produced cyanide excreted by plants, micro-organisms and insects; and the third is manufactured cyanide. Incorrect conclusions can easily be drawn, with potentially serious consequences if valid measurements are not used" pp 14

Following from these conclusions it is recommended that a total cyanide WQO of 0.1mg/L is set for the Project. If this value is exceeded further investigation may be warranted.

[4] The default WQO for beryllium (0.00013 mg/L) is below the standard LOR of 0.001 mg/L, therefore it is not possible to accurately assess concentrations against the WQO.

[5] There is no scheduled default physico-chemical stressor guideline value for nitrate in the Gulf Rivers region. There is currently insufficient data available to establish a site-specific value for nitrate and there is a lack of published data available for an adjacent similar catchment, therefore the ANZECC (2000) trigger value for the protection of 95% species is applied. Nitrate monitoring in the receiving environment will form part of the REMP in order to gather sufficient information to establish a site-specific WQO for nitrate.

3.3.1.1 Hardness Modified Trigger Values

The default trigger values outlined in Table 2 can be modified to account for water hardness. Hardness influences the biological uptake of toxicity of dissolved cadmium, chromium (III), copper, nickel, lead and zinc. Subsequently the above trigger values can be adjusted to allow for water hardness. Trigger values for these parameters should be adjusted for hardness based on the equations outlined in Table 3. HMTV's should only be calculated if the hardness in the water exceeds 25mg/L as $CaCO_3$.

Where a HMTV is calculated it should be recorded in the water quality database and an assessment on a sample by sample basis undertaken to determine if dissolved concentrations in the sample exceed the hardness modified trigger value.

Table 3 Equations to calculate hardness modified trigger values (from ANZECC, 2000)

Parameter	Equation
Cadmium	$TV * (Hardness / 30)^{0.89}$
Chromium (III)	$TV * (Hardness / 30)^{0.82}$
Copper	$TV * (Hardness / 30)^{0.85}$
Lead	$TV * (Hardness / 30)^{1.27}$
Nickel	$TV * (Hardness / 30)^{0.85}$
Zinc	$TV * (Hardness / 30)^{0.85}$

3.3.2 Sediment Quality Guidelines

Sediment trigger level and contaminant limits are based upon ANZECC/ARMCANZ (2013) Sediment Quality Guidelines and are presented, where present, for relevant parameters in Table 4. The recommended approach is to calculate the median background concentration and multiply this by a certain factor (typically two) (Simpson, Graeme, & Chariton, 2013). This approach is applied to EAs of mine sites throughout Queensland and allows site-specific concentrations of the above contaminants to be provided.

Where replicate samples are taken at a monitoring site, an exceedance is taken to be where the 95th percentile of the replicate samples exceeds the guideline value as outlined in Table 4. Where the replicate samples from an impact site are compared to replicate samples from a reference site, an exceedance is taken to be where the 95th percentile of the impact site exceeds the maximum at the reference site.

Table 4 Trigger levels and contaminant limits for stream sediments

	Units	Trigger Level~	Contaminant Limit
Arsenic	mg/kg	20[1]	70[2]
Cadmium		1.5[1]	10[2]
Chromium		80[1]	370[2]
Copper		65[1]	270[2]
Lead		50[1]	220[2]
Mercury		0.15[1]	1.0[2]
Nickel		21[1]	52[2]
Zinc		200[1]	410[2]
Other Parameters	As relevant	Where there is no guideline provided specifically, the trigger level is to be the value of the reference site and the contaminant level is to be three times the value at the reference site.	

~ Trigger values can be those found in this column or the value from the reference site, whichever is higher

[#] Contaminant limits can be the values found in this column, or three times the reference value, whichever is higher

[1] Value from "Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (Simpson, Graeme, & Chariton, 2013) "Guideline Value"

[2] Value from "Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (Simpson, Graeme, & Chariton, 2013) "SQG-High"

3.4 Summary of Receiving Environment

The following summary of the receiving environment is presented from the IAR for the K2H Project:

Surface Water Quality

- EVs for the Gilbert River basin have not been defined under the EPP Water. In this instance, the EPP Water prescribes the application of all default EVs. EVs have been described for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River.
- Macroinvertebrate data supports the distinction of a 'Slightly Disturbed' aquatic ecosystem condition under the EPP Water. The management intent for this water type is to gradually improve water quality and to aim to achieve a HEV waterway classification, however HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality.
- The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. Where applicable, site-specific trigger values were derived based on the upstream dataset for monitoring location WB. HMTVs were developed for the area in the immediate vicinity of the release point, using the median baseline hardness values at monitoring location W2.
- Some anomalies in the receiving environment water quality datasets were noted and led to the exclusion of samples collected prior to 2012 (providing an adequate dataset size for analysis of 40 to 60 samples). Ongoing monitoring is recommended for parameters with limited dataset sizes.
- The baseline assessment indicated that a number of parameters are elevated above WQOs in the receiving environment. Monitoring site W2 has indicated potential impacts from seepage.

Hydrology

- In the absence of stream gauging, hydrological modelling was used to undertake a flow spells analysis which showed a definite seasonal distribution with a distinct high flow season occurring from December through April.
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).

Hydrogeology

- The groundwater flow regime of the Project has been modified by the construction of the tailings dam, interception drains, and by dewatering of the two pits. In their current state, Wises Pit and Eldridge Pit are both understood to function as groundwater 'sinks', as groundwater levels in the surrounds of both pits are higher than the surface water level in the pits.
- One confirmed wetland spring, Middle Spring, lies within the vicinity of the mine area. This spring is located west-northwest of the former mine and is not considered to be hydraulically connected to the groundwater regime of the proposed release area.

Sediment Quality

- The braided nature of the Copperfield River results in sediment transport that is limited to a few months per year during the wet season when discharge is high enough. Very little fine sediment is stored in the channel bed in the upper to mid catchments.

- Sediment samples have been collected annually between 2009 and 2013. No whole-sediment samples exceeded the SQG, indicating that sediment within the Copperfield River is considered to be unaffected by the historical mining processes. Although the <0.063 mm samples reported a number of SQG exceedances, this fraction is considered less useful for comparison to guideline values.
- For toxicants in the <0.063 mm fractions, exceedances reported around the potential release sites (e.g., W1 and W2) are also reported in the upstream and downstream monitoring sites (e.g., WB and W3, respectively) suggesting that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage. Additional sampling and monitoring is recommended in accordance with the REMP.

Aquatic Ecology

- The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling determined that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented.

Dry Season Survey

- Six semi-permanent waterholes were identified within the floodplain of the Copperfield River through a drone flyover in September 2018. These waterholes were sampled in late September 2018, along with monitoring locations W1 and W3.
- Previous significant rainfall in the catchment occurred in March 2018, therefore the water in the pools is assumed to have been standing for a long duration and were likely subjected to evapo-concentration.
- Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.
- A comparison against the long-term (post 2011) dataset for W1 and W3 did not indicate any clear trends with regards to water quality.

4.0 Monitoring Program Design

The aims of the monitoring program are to detect changes to the natural environment downstream of the K2H project as a result of controlled releases. The following sections outline requirements for the following types of monitoring to achieve this aim:

1. Water quality;
2. Sediment;
3. Biological,
4. Flow, and
5. Groundwater

An overview of the monitoring program for the Project, including monitoring locations and frequencies is presented in Appendix A. Further detail regarding methodologies and parameters for water quality, sediment, biological monitoring and flow is presented in Sections 4.1, 4.2, 4.3, 4.4 and Section 4.5 respectively.

Monitoring locations and sampling regimes (Appendix A) have been designed to appropriately monitor environmental variables from areas upstream of any impact from historical mining activities, as well as near-field and far-field monitoring. Sample locations have been added downstream beyond the historical REMP monitoring locations to evaluate potential impacts to the Einasleigh River as a result of water releases from the Project. Water quality is to be monitored at the Einasleigh Gorge in order to record water quality trends in this location.

4.1 Water Quality Monitoring

4.1.1 Routine Sampling Locations and Frequency

Water quality sampling locations and frequencies are listed in Appendix A.

4.1.2 Field Quality Control

The collection of quality control samples is essential in order to provide confidence in the results of a sampling program, and is part of the overall quality assurance program. Quality control samples are listed in Table 5.

Table 5 Quality Control Samples

Quality Control Sample	Number of quality control samples to be collected	Notes
Rinsate/Equipment Blank	One per field team per trip	The equipment blank assesses the potential for cross contamination of samples due to insufficient decontamination of sampling equipment.
Duplicates	One per 10 samples	Assesse the precision of results within a laboratory and between laboratories.

Source: Adapted from DES 2018

4.1.3 Sampling Equipment

- Field meter capable of reading pH, EC, temperature, TDS, turbidity and dissolved oxygen. ORP is preferential but not required;
- Sample bottles;
- Extendable sampling pole;
- Field filters for metals;
- Laboratory equipment;

- Adequate field sheets;
- Rinsate for field blanks;
- Deionised water for decontamination;
- Disposable nitrile gloves.

4.1.4 Water Quality Monitoring Parameters and Limits of Reporting

Each water quality sample should be analysed for the parameters listed in Table 6 and at the Limit of Reporting (LOR) specified.

Table 6 Water quality monitoring parameters and limits of reporting

Parameter	Units	LOR
Physico-Chemical		
pH (field + laboratory)	pH	0.1 pH units
EC (field + laboratory)	µS/cm	1 µS/cm
Total Suspended Solids (laboratory)	mg/L	5 mg/L
Turbidity (field + laboratory)	NTU	0.1 NTU
Dissolved Oxygen (field)	mg/L and % saturation	
Redox Potential (field)	mV	0.1 mV
Temperature (field)	^{o}C	0.1 ^{o}C
Cations / Anions		
Calcium	mg/L	1 mg/L
Magnesium		1 mg/L
Sodium		1 mg/L
Potassium		1 mg/L
Sulfate as SO_4		2 mg/L
Chloride		1 mg/L
Alkalinity		1 mg/L
Hardness		1 mg/L as $CaCO_3$
Fluoride		0.1 mg/L
Metals (total and dissolved)		
Aluminium	mg/L	0.01 mg/L
Arsenic		0.001 mg/L
Barium		0.001 mg/L
Beryllium		0.001 mg/L
Boron		0.001 mg/L
Cadmium		0.0001 mg/L
Chromium		0.001 mg/L
Cobalt		0.001 mg/L
Copper		0.001 mg/L
Manganese		0.001 mg/L

Parameter	Units	LOR
Mercury#		**0.00006 mg/L#**
Nickel		0.001 mg/L
Lead		0.001 mg/L
Selenium		0.01 mg/L
Vanadium#		**0.006 mg/L#**
Uranium#		**0.0005 mg/L#**
Zinc#		**0.002 mg/L#**
Iron		0.05 mg/L
Nutrients		
Total Phosphorous	mg/L	0.01 mg/L
Organic Nitrogen as N		0.01 mg/L
Total Nitrogen		0.01 mg/L
Ammonia as N		0.01 mg/L
Nitrate		0.01 mg/L
Nitrite		0.01 mg/L
Other		
Dissolved Organic Carbon	mg/L	1 mg/L
Cyanide - Total		0.004 mg/L
Cyanide – Free		0.004 mg/L
Total Organic Carbon		1 mg/L
Chlorophyll a	mg/m^3	1 mg/m^3

These parameters require “ultra-trace” analysis to reach the recommended LOR. This will require larger sample containers and higher volumes of water and must be specifically marked on the Chain of Custody (COC) form.

4.1.5 Sampling Method

The following methodology should be employed to collect all in situ and grab water samples (Barrack Australia, 2013):

1. Ensure that the field meter is appropriately calibrated before starting fieldwork. Calibrate to manufacturer’s specifications and maintain a calibration record.
2. Upon arrival at a sample site, turn on the field meter and place the probes in the stream, pond etc. to be sampled. This will allow the probes to equilibrate with the sample conditions while performing the other sampling tasks. Once having completed all other sampling tasks and just prior to leaving the site, record the readings from the field meter.
3. Using a new pair of disposable nitrile gloves, open the zip-lock plastic bag containing the sample bottles and write the necessary details on the bottle label.
4. While still wearing the disposable nitrile gloves and using the green labelled 1L plastic sample bottle, without removing the lid submerge the bottle into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). Facing upstream, to ensure the bottle is upstream of your body or any disturbance caused to the stream bottom by your presence. Open the lid with your free hand, allow the bottle to fill and then close the lid whilst still under water. Withdraw the sample from the water.

5. The same procedure in Step 3 is to be followed with the 50ml red/green bottle for “total” metal analysis. However, using a permanent ink marking pen, place a “tick” in the “Total Metals” box on the red/green sample bottle label.
6. The following sample bottle types contain preservative chemicals and or have been specially treated and must not be used as in Step 3:
    a) 50ml red/green sample bottle for “filtered” (dissolved) metal analysis;
    b) 250ml blue sample bottle for cyanide analysis;
    c) 50ml blue sample bottle for chromium analysis;
    d) 50ml clear sample bottle for arsenic analysis.
7. If one of the bottle types from (b) to (d) listed in Step 5 is required, while still wearing the disposable plastic gloves, remove the lid from the bottle and place it thread facing up on the ground (to avoid any soil/sediment etc. entering the bottle when the lid is later replaced). With the sample collected in the green labelled 1L plastic sample bottle from Step 3, carefully fill the bottle to nearly full but ensuring that the bottle does not overflow. Since bottle types from (b) to (d) listed in step 5 have various chemical preservatives added, if the lids from these bottles are swapped this will introduce gross contamination. Ensure that the correct lid from each bottle is used when being replaced.
8. After filling any necessary bottles, Step 3 is to be repeated with the green labelled 1L plastic sample bottle.
9. For “dissolved” (“filtered”) metal analysis , while still wearing the disposable nitrile gloves, with a new 50ml plastic syringe:
    a) Submerge the syringe into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). While facing upstream, ensuring the syringe is upstream of your body or any disturbance caused to the stream bottom by your presence, draw back the plunger to fill the syringe. Remove the syringe from the stream or pond and dispose of the sample downstream.
    b) Repeat this twice to ensure the syringe has been thoroughly rinsed.
    c) With a syringe full of water sample as per step 7a, rinse the outside of the syringe and your gloved hands with rinse water. Then gently shake the syringe and your gloved hands to remove as much adhering water droplets as possible. This is to ensure no unfiltered droplets of water containing sediment/soil are accidently allowed to enter the 50ml red/green sample bottle for “filtered” metal analysis.
    d) Remove a 0.45µm filter disc from the wrapper and attach the filter disc to the bottom of the syringe prepared in step 7b. Press the plunger to filter the sample allowing the first approximately ten (10) drops to be discarded onto the ground. Filter the remaining volume in the syringe into the 50ml red/green sample bottle for “filtered” (dissolved) metal analysis. The syringe/filter disk is then discarded (do not reuse between sites).
    e) Using a permanent ink marking pen, place a “tick” in the “Dissolved Metals” box on the red/green sample bottle label.
10. Once all the necessary bottles have been filled, each is to be externally washed with rinse water to ensure any adhering soil or sediment is removed. Gently shake to remove as much adhering water as possible, and then return to the sample bottle to zip-lock plastic bag.
11. The samples are to be sent to a National Association Of Testing Authorities (NATA) Australia accredited laboratory in an iced plastic sample esky for analysis as soon as possible after collection.

For each sampling event, a photographic record of the following should be taken:

1. Upstream of the sample point;
2. Downstream of the sample point;

3. Any erosion present at the sample point;
4. Significant aquatic and riparian vegetation or noted changes in vegetation at the sample point; and
5. Anything else that is observed to potentially contribute to the water quality conditions at the site.

Once the parameter readings have stabilised they should be recorded on a field sheet, along with the following information:

- Site name;
- Brief site description (e.g. location and obvious environmental elements);
- Date and time of sampling;
- Weather at the time of and preceding sampling;
- General site observations including presence of weeds, animal tracks, site degradation and environmental health;
- The presence and / or state of any inflows or outflows to the site;
- Estimated maximum depth and width of the water body/watercourse at the point of sampling;
- Depth at which the parameters were recorded;
- Appearance of the water, including water clarity and colour;
- Water odour; and
- Substrate material at the site.

4.1.6 Data Handling and Reporting

Upon receipt of samples from the laboratory, the following methods should be employed:

1. If quality characteristics of any downstream samples exceed the WQOs specified in Table 2, compare downstream results to the upstream results, and:
    a. Where the downstream results are lower than the upstream results, no action is to be taken;
    b. Where the downstream results are higher than the upstream results, notify the administering authority within 24 hours of receipt of the results; AND
    c. Complete an investigation into the potential for environmental harm and provide a written report to the administering authority within 90 days of receiving the result, outlining:
        i. Details of the investigation carried out;
        ii. Actions taken to prevent environmental harm.

4.2 Sediment Monitoring

4.2.1 Initial Sediment Investigation

Existing sediment quality data suggests that levels of zinc and arsenic in the <0.063mm fraction are elevated above trigger values in the receiving environment at W1 and W2, and that other metals are elevated at multiple sites including the upstream monitoring site (AECOM, 2018).

An initial stream sediment investigation is proposed to be undertaken prior to the commencement of the Project to characterise the metal concentrations and behaviour in the Copperfield River prior to the commencement of releases.

There is inherent variability in sediment sampling results, particularly in metals analyses. Subsequently the aims of this initial investigation are to:

- Undertake sufficient sediment sampling for suitable parameters and analyse the <0.063mm fraction;
- Undertake sufficient replication of samples to characterise a 'true' sediment level and remove uncertainty regarding variability of results arising from the nature of stream sediment sampling; and
- Characterise elements that may be above trigger and contaminant limits from upstream sampling sites.

This initial study should collect at least five (5) replicate samples from each monitoring site using the collection methods outlined in Section 4.2.3. Sample locations are identified in Appendix A.

Each sample should be separated into a <0.063mm fraction and a <2mm fraction and each fraction analysed for the parameters outlined in Table 7 by a NATA accredited laboratory. Samples should be taken in the dry season prior to the onset of the wet season when the majority of waterholes have dried up.

The aim of the initial sediment study is to characterise variability of concentrations in sediment from replicate samples, to determine if there is a consistent trend found at each site, or whether there is inherent variability in the sediment results. The outcomes of the initial sediment study will govern whether replicate samples are required for ongoing sediment monitoring. In addition the replicate sediment study will also aim to determine the pre-existing concentrations in sediment along the Copperfield River before releases commence.

4.2.2 Routine Sampling Locations and Frequency

Sediment sampling locations and frequencies are listed in Appendix A. Samples should be taken from areas of fine sediment deposition. This can include scour holes or at the upstream or downstream end of naturally occurring waterholes. Sediment samples should always be targeted in the mobile-bed of the river in sediment has recently been deposited. Sediment samples should not be obtained from areas where there has been no sediment movement in years.

4.2.3 Sampling Method

Field sampling for sediments will be undertaken in accordance with the Sediment Quality Assessment Guidelines as well as the Australian Standard (AS/NZS 5667.12:1999). A plastic (HDPE or PTFE) sampling trowel will be used to scoop sediments into a suitable sample container ready for sieving. At least 2kg of sample will be collected prior to sieving.

There is significant risk that the samples submitted to the laboratory will not have enough volume to analyse the <0.063mm fraction. If the NATA accredited laboratory does not have enough volume to analyse the <0.063mm fraction, the laboratory LOR will be artificially raised. Instructions on handling laboratory results with artificially raised LORs are provided in Section 4.2.5.

Sediment samples are to be collected from the top 0.3m of sediment on the bed using a plastic trowel. Sediment sampling locations should target areas of fine sediment, such as at the downstream end of scour holes or depressions within the bed. Sampling is to target newly deposited sediment where ever possible. The location of the sediment sample should be recorded and photographed and effort should be made to take future samples from the same location in order to determine changes over time.

A photographic record of the monitoring location will be taken during each sampling event, including upstream, downstream and the actual sample site.

4.2.4 Field Quality Control

As specified in DES 2018, one duplicate sample should be collected per 20 samples (minimum of one per field trip).

4.2.5 Sediment Quality Monitoring Parameters and Limits of Reporting

As discussed above, each sample should be sieved to <0.063mm and <2mm fractions. Each fraction should be analysed for the parameters outlined in Table 7.

Following the collection of five years of sediment quality data post releases, the data will be evaluated. If any of the monitored parameters have not been recorded at levels above the LOR for more than 80% of the record, and the concentrations of those parameters do not exceed trigger levels, SQG-High or reference site concentrations, they can be removed from the analysis.

Table 7 Sediment quality monitoring parameters and limits of reporting

Parameter	Units	LOR (for both the <0.063mm fraction)
Physical Parameters		
Particle Size Distribution	%	1
pH	pH units	0.1
Cation Exchange Capacity (CEC) including exchangeable aluminium	mg/kg	1
Total fluoride	mg/kg	1
Sulfate – Total as SO4	mg/kg	1
Metals		
Aluminium	mg/kg	50
Arsenic	mg/kg	5
Barium	mg/kg	10
Beryllium	mg/kg	1
Boron	mg/kg	50
Cadmium	mg/kg	1
Chromium	mg/kg	2
Cobalt	mg/kg	2
Copper	mg/kg	5
Nickel	mg/kg	2
Manganese	mg/kg	5
Mercury	mg/kg	0.1
Lead	mg/kg	5
Selenium	mg/kg	5
Vanadium	mg/kg	5
Zinc	mg/kg	5

Parameter	Units	LOR (for both the <0.063mm fraction)
Other		
Cyanide - Total	mg/kg	1
Total Nitrogen	mg/kg	20
Total Phosphorous	mg/kg	2

4.3 Biological Monitoring

4.3.1 Routine Sampling Locations and Frequency

Biological monitoring locations and frequencies are listed in Appendix A.

4.3.2 Aquatic Habitat and Flora

Aquatic ecology can be greatly influenced by habitat factors at the time of sampling. For this reason a detailed habitat assessment will be undertaken at each site where macroinvertebrate sampling or sampling for higher-order aquatic fauna is undertaken. The habitat assessment will be undertaken in accordance with the AusRivas methodology (DNRM, 2001). Care must be maintained to sufficiently describe the bed and edge habitat separately as well as any gradients between the two.

The habitat assessment will focus on rating:

- Bottom substrate / available cover;
- Embeddedness;
- Velocity / depth category;
- Channel alteration;
- Bottom scouring and deposition;
- Pool / riffle, run/band ratio;
- Bank stability;
- Bank vegetative stability;
- Streamside cover.

The condition of the above elements is to be scored in accordance with the Queensland AusRivas Sampling and Processing Manual. For each site, each element above must be scored either as “Poor”, “Moderate”, “Good” or “Excellent” and provided a score in accordance with the AusRivas Sampling and Processing Manual. The score of each element is then added to provide an overall habitat assessment score for each site to allow comparison.

4.3.3 Macroinvertebrate monitoring

The composition and abundance of macroinvertebrates is a key indicator of the health of aquatic ecosystems. There are various methods to sample and analyse macroinvertebrates. In ephemeral environments the life-history strategies of aquatic fauna have evolved in response to seasonal flow regimes. Therefore the timing of rainfall, floods and the persistence of pools are the main driving forces for macroinvertebrate community composition and abundance.

There are two methods nationally used for collecting aquatic macroinvertebrates. Both methods involve sampling a defined length of habitat using a dip net. However the samples that are collected can be live picked, or stored for laboratory picking of the sample. This method has been used throughout Queensland to set WQOs for various macroinvertebrate indices and is suitable for comparison of sample results to these WQOs.

As outlined in the 2018 Aquatic Ecology Study (C&R Consulting, 2018) there are no WQOs defined for the Gilbert River catchment. Instead the initial aquatic ecology characterisation of the area compared macroinvertebrate indices to those from the Central Queensland region given that the geomorphology and aquatic habitats in the Copperfield River are similar to those in Central Queensland. This approach is not sufficient for ongoing monitoring of potential impacts from the Kidston project.

The approach for ongoing macroinvertebrate monitoring of the Kidston Project is to undertake quantitative analysis of macroinvertebrate samples. This involves field collection of macroinvertebrates in accordance with the AusRivas method but excludes live picking of macroinvertebrates in the field. Instead all macroinvertebrates collected are preserved and sent for laboratory analysis. This allows quantitative analysis of the sample and comparison between sample sites using multivariate analyses.

The field picking method as outlined by AusRivas is not quantitative as it does not identify and quantify all individuals in the sample; instead the results are used in a presence-absence AusRivas model to broadly indicate ecosystem health. Laboratory picking involves transport of the entire sample to a laboratory for identification of all collected macroinvertebrates. Mutlivariate analysis is then undertaken on the results and the similarity of sample sites can be quantitatively defined. This approach is preferred for the detection of impacts from point source pollution (Smith, Jeffree, John, & Clayton, 2004). Downstream sites are compared to upstream sites, rather than all sites being compared to regional WQOs (which, for the Kidston site, may not be representative as the WQOs are for Central Queensland).

4.3.3.1 Quantitative Macroinvertebrate Sampling Methodology

Three replicates of edge habitat and three replicates of bed habitat samples will be collected using the following methods which are broadly in accordance with AusRivas protocols, but modified for the quantitative macroinvertebrate analysis technique.

In areas of fast flowing water

- Use a surber sampler with an area of 0.3m by 0.3m and fitted with 250µm mesh.
- Disturb the 0.3m by 0.3m area to a depth of 5cm for a total of 5 seconds and then sweep the 250µm mesh through the disturbed area 5 times.

In areas of slow flowing water or still water

- Place a 0.3m by 0.3m quadrat and disturb the area to a depth of 5cm.
- Sweep a standard 250µm triangular mesh through the disturbed area 5 times.

Following Sample Collection

- Preferably wash all samples collected through nested sieves (8mm and 250mm) to remove excess organic matter and detritus. However this will be at the discretion of the sampler. It should be noted whether this was conducted within the reporting.
- Transfer the sample to screw top jars and preserve with 70% ethanol for laboratory analysis.
- Laboratory analysis is to identify all individuals to the family level taxonomic level consistent with AusRivas taxonomic resolution. The exception is the microcrustacean taxa (Cladocera, Copepoda, Ostracoda).

Each replicate should be collected from a homogenous macrophyte habitat with greater than 50% cover at all sites for edge habitat to reduce false positives in impact detection as a result of different habitat characteristics. Generally edge and bed habitat sample replicates should be taken from the same location each year. Variations can be added from year to year based on changing habitat conditions such as macrophyte cover. As the Copperfield River is braided, macroinvertebrate samples should be collected from the braid that is known to contain release waters in all near-field sites. Specific sample locations at upstream monitoring sites should target the braid which will receive release water. Far-field sites should be sampled in the same manner year after year (i.e. the same number of replicates should be collected from the same side of the bank as the previous year).

4.3.3.2 Coincident Macroinvertebrate and Water Quality Analysis

Water quality analysis should occur at the same time as macroinvertebrate monitoring. If scheduled, routine water quality samples (as scheduled in Appendix A) are not gathered at the same time as macroinvertebrate monitoring, water quality samples should be collected and analysed for the following parameters:

Table 8 Minimum water quality analyses to be undertaken with macroinvertebrate monitoring

Grouping	Parameter	Units
In-Situ water quality parameters (field meter)	pH	pH unit
	Electrical conductivity	µS/cm
	Turbidity	NTU
	Dissolved Oxygen	mg/L and % saturation
	Temperature	^{0}C
Cations/Anions (laboratory analysis)	Sulfate as SO_4	mg/L
	Calcium	mg/L
	Magnesium	mg/L
Total and dissolved metals	Aluminium	mg/L
	Copper	mg/L
	Iron	mg/L
	Manganese	mg/L
	Lead	mg/L
	Uranium	mg/L
	Zinc	mg/L

4.4 Flow

Continuous (i.e. 15 minute intervals) flow monitoring will be undertaken in the Copperfield River upstream (at monitoring site US1) and downstream of the proposed release location (at monitoring site DS1). The monitoring station and associated equipment will be maintained and calibrated in accordance with manufacturer's instructions. A rating curve for the gauge will be established and regularly updated. In situ water quality parameters including temperature, pH, EC and DO will also be continuously measured at the stations.

4.5 Groundwater

The Copperfield River, at the proposed release area, drains through Quaternary alluvial sediments which directly overlie the Einasleigh Metamorphics.

The alluvial sediments (comprising clay, silt, sand, and gravel) extend laterally from the river bed as flood-plain alluvium. Drilling indicates limited thickness of alluvial sediments within the Copperfield River, some 5 to 6 m. The Einasleigh Metamorphics, predominantly biotite gneisses, outcrop adjacent to, and in some sections within, the Copperfield River.

Regional groundwater flow within the alluvium is considered to mimic the topography of the Copperfield River and subsequent flow direction, generally north. The hydrological regime of the Copperfield River is ephemeral; flows are highly episodic and likely sustained only during and immediately after significant rainfall events and the wet season. The locations of semi-permanent waterholes within the floodplain of the Copperfield River were identified through flyover with a drone by Genex in September 2018. Six locations were identified. Standing water was present at long term monitoring points W1 and W3 as well.

The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

The presence of semi-permanent pools suggests the river is, at least for some parts of the year, fed by groundwater discharge. The fact that the pools do not persist throughout the year indicates that the groundwater source aquifer (likely the alluvium in the surrounds of the river) has limited storage. Groundwater inflows to the river are potentially sourced from surface water that has infiltrated the alluvium when the river is in flood.

Limited hydrochemistry data for the alluvium associated with the Copperfield River is available. Groundwater quality monitoring data provided by Genex was assessed and bore reports from the DNRME registered GWBD were interrogated for groundwater quality data in proximity to the proposed release area.

Two registered bores are reported to be constructed to intersect the floodplain alluvial sediments of the Copperfield River, RN139937 (BA06) and RN139938 (BA07) located adjacent to the mine pits and north and south of the proposed release area.

The available groundwater quality data for these bores, provided by Genex, comprises monitoring from October 2008 through October 2017, which includes some seasonal variability (wet and dry season monitoring) and spatial variability.

- The available data from monitoring bore BA06 indicates magnesium/calcium-sulphate-rich water quality. Sulphate concentrations have varied throughout the monitoring period but generally ranged between ~ 2,500 and 3,000 mg/L, although a marked increase was observed in January 2017, to ~ 5,000 mg/L.
- The available quality data for monitoring bore BA07 indicates a greater proportion of dissolved sodium and chloride, and lower dissolved sulphate concentrations (< 1,000 mg/L) than bore BA06. The January 2017 sulphate ‘spike’ observed in BA06 was also observed in water quality from BA07 sampled on the same date; however, sulphate concentrations reported subsequently decreased in both bores (to < ~ 1,000 mg/L). Electrical conductivity trends mirror sulphate concentrations.

Samples from both bores record relatively high alkalinity (~ 200-500 mg/L) and pH has remained consistently between 7 - 8 for both bores throughout the monitoring period. Recorded dissolved metal concentrations are generally at or below laboratory LOR in samples from both monitoring bores.

The location of BA07 (just east and down topographic gradient from the former mine pits) and the marked variation in water quality from bore BA06, suggest that seepage from the former mine area may be acting as artificial recharge to the alluvial sediments in proximity to the proposed release area.

Monitoring of these two bores (BA06 and BA07) is to occur as part of the REMP to quantify any linkages between the pits and the Copperfield River. The locations of these bores as well as monitoring frequencies are found in Appendix A.

4.5.1 Sampling Methods

4.5.1.1 Water Level Monitoring

Sampling should be undertaken in accordance with the following method:

1. Assess the monument and/or casing and cap for any signs of damage or changes.
2. Open the monument or remove the casing and cap.
3. Use a water quality dipper such as a Solinst Water Level Meter. Turn it on and gently lower the probe into the water column. Take care to prevent the tape from rubbing on the edge of the casing or monument as this will make it fray and can disrupt the electrical signal used to indicate water.
4. Once the alarm sounds, gradually raise the probe again until the alarm stops. Lower again slowly until the alarm sounds to record the water level.
5. Enter the Standing Water Level from the reference location (top of casing) into the field sheet.
6. If no further monitoring is to take place, ensure the cap is placed tightly back on the bore casing.

This is to be undertaken prior to any groundwater sampling to record the standing water level prior to disturbance.

4.5.1.2 Groundwater quality sampling

Groundwater quality sampling is to be undertaken with *Groundwater Sampling and Analysis – A Field Guide* (Geoscience Australia, 2009). Generally there are two different methods to sample bores, including:

- Bore purge method;
- Low flow sampling.

Please refer to the latest copy of the above document for further information regarding sampling using these methods. The choice of method will be at the discretion of the sampler. However, once a bore is sampled using one method, future samples should also use the same method to provide as consistent results as possible.

Water quality samples cannot be collected using either method until field parameters have reached stabilisation limits. The stabilisation limits are provided in Table 9. Three consecutive samples, taken at least 2 minutes apart, must be within the tolerances outlined in Table 9 until sample bottles for laboratory analysis can be filled.

Table 9 Stabilisation parameters for low flow sampling

pH	ORP	EC	DO	Temperature
± 0.1	± 10mV	± 5%	± 10%	± 0.2 degree

4.5.2 Sample Parameters

All groundwater samples should be analysed for the parameters outlined in Appendix A to provide as consistent results as possible.

5.0 Data Interpretation

5.1 Overview

All data collected for the REMP is to be analysed and discussed in an annual REMP Assessment Report to be submitted in October of each year. The REMP Assessment Report will review all data collected for the receiving environment and assess against current triggers and guidelines. The REMP Assessment Report will also determine whether the current release regime is suitable and will outline what impacts are occurring in the receiving environment.

5.2 Water Quality

5.2.1 Values below the Limit of Reporting

Values that are returned from the laboratory below the LOR should be transformed to 50% of the LOR. For example, a value of <0.001 mg/L becomes 0.0005mg/L.

5.2.2 Data Requirements for Background Data

The QWQG 2009 provides a framework for developing locally relevant WQOs. Background data can be used if samples are collected from a suitable location and there are enough samples collected over a relevant time period. It is preferable to have 18 samples over 24 months. (Claus, Dunlop, & Ramsay, 2017). Until minimum data requirements have been established, comparison of test site medians should be made with reference to the default guidelines. A discussion of the water quality monitoring sites and data suitability is outlined below.

5.2.3 Assessing compliance with WQOs

Compliance assessment is not as simple as comparing individual water quality samples to the WQOs listed in Table 2. The method to assess whether a WQO has been exceeded depends on the parameter type. These are summarised below (for Slightly to Moderately Disturbed waters):

- **Physical and chemical stressors**[2]

  Trigger values are exceeded when the median of at least 8 samples (preferably 24 collected over a 2 year period) at a test site exceed the WQO. Or if suitable background data exist, when the median of the 8 to 24 samples exceeds the 80th percentile of the reference site (from the same number of samples), the trigger investigation level is exceeded (ANZECC (2000) Guidelines, Section 7.4.4.1).

- **Toxicants**[3]

  A trigger value is exceeded when the 95th percentile of the test distribution exceeds the default value; no action is triggered if 95% of all values fall within the default WQO.

  If background data exists, compare the 80th percentile of background data (calculated over at least 10 to 24 samples gathered over the previous 24 months) to the default WQO. If the 80th percentile exceeds the WQO, then the 80th percentile becomes the new WQO and exceedance occurs if the running median (from the same period of samples) of the test site exceeds the running 80th percentile of background data. (EHP, 2013).

Statistical measures (medians, 80th percentiles, 95th percentiles) should be calculated from the most recent 10 to 24 samples. Where an exceedance of the default WQO applies, the entire dataset should be investigated in further detail.

With reference of comparison of site data to ANZECC (2000) WQOs for Aquatic Ecosystems it is important to note that Section 3.4.3.2 of the ANZECC (2000) guidelines states:

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[2] Includes nutrients, biodegradable organic matter, dissolved oxygen, turbidity, suspended particulate matter, temperature, salinity, pH.

[3] Includes ammonia, heavy metals and other toxic compounds

"… Comparison of total concentrations will, at best, overestimate the fraction that is bio-available. The major toxic effect of metals comes from the dissolved fraction so it is valid to filter samples (e.g. to 0.45µm) and compare the filtered concentration against the trigger value" (pp 3.4-15)

Site data from 'filtered' samples are compared to default WQOs for Aquatic Ecosystems; however, if the WQO is sourced from an alternate EV (such as recreation or cattle drinking etc.) the 'total' concentration from site data is compared.

5.2.4 Dissolved and Total Metals

A comparison should be made between dissolved and total concentrations of metals in each sample. Where the dissolved concentration exceeds the total concentration, the laboratory should be queried for possible reasons.

If the dissolved concentration is greater than the total, the following checks will be undertaken:

1. Assess the precision of the method and compare concentrations in duplicate samples.
2. Check total suspended solids concentrations. If concentrations are low, this indicates that total and dissolved concentrations will be the same or very similar.
3. If the results of Steps 1 and 2 above are inconclusive, ask the laboratory to check their results.

5.2.5 Data Analysis

Water quality test site results will be compared with both WQOs and control site water quality. As a minimum, a condition assessment will be conducted over an annual cycle to allow sufficient time to gather data for statistical analysis over various flows (base flow and high flow) and to take into account seasonal periods. Any raw data used in the analysis will also be included in the reporting, along with suitable reporting statistics (e.g. 20th, 50th, 80th, 95th percentiles).

Potential causes for any exceedances of WQOs and potential effects on EVs will be assessed. Long-term trends will be assessed once sufficient data has been accumulated.

5.3 Sediment Quality

5.3.1 Values below the Limit of Reporting

Where the standard LOR is achieved, values that are returned from the laboratory below the LOR should be transformed to 50% of the LOR. For example, a value of <1 mg/kg becomes 0.5 mg/kg.

Since the <0.063mm fraction is being analysed, there is a significant risk that the volume of each sample <0.063mm is not sufficient for the laboratory to obtain suitable LORs. For example if there is not enough sediment volume, the sample in the <0.063mm fraction may show <10 mg/kg instead of <1 mg/kg. In these instances the following hierarchy should be followed:

1. If the value below the LOR is below SQG Trigger Levels or SQG High, transform the value to 50% of the LOR. For example, if the concentration of lead is returned as <40 mg/kg, transform the value to 20mg/kg.
2. If the value below the LOR is above SQG Trigger Levels and SQG High, record the sample as exceeding the SQG Trigger Level. For example, if the concentration of lead for a sample is returned as <60mg/kg (and the SQG Trigger Level is 50mg/kg), record the sample as exceeding the SQG Trigger Level.
3. If the value below the LOR is above the SQG-High, record the sample as possibly exceeding the SQG High. For example if the concentration of lead for a sample is returned as <300 mg/kg (and the SQG-High value is 220mg/kg), record the sample as possibly exceeding the SQG High value. Re-sampling may be required in this instance as there was a very low volume of sediment provided to the laboratory in the <0.063mm fraction.

5.3.2 Site Variability

The nature of stream sediment sampling means that there is a high degree of uncertainty regarding the composition of sediment and the subsequent results of metals analysis. Stream sediment is comprised of a number of different weathering products from a range of host geologies. Any given sample of sediment will have different relative compositions of mineral particles, potentially altering the results of subsequent metals analysis by a NATA accredited laboratory.

In addition the grain size distribution will affect results. Total sediment samples (comprising all grain sizes) as well as samples sieved to the <0.063mm fraction (clays and silts) were analysed between 2009 and 2013 at the former Kidston mine. The total samples recorded zinc concentrations in the order of 5 to 70mg/kg with the majority of values around 10 to 15mg/kg. The <0.063mm fraction recorded concentrations in the order of 100-300 mg/kg with one sample showing a value of 431 mg/kg. The higher values are a result of the higher surface area available for adsorption and desorption in the finer fraction of sediment. This fraction is also the most bio-available to aquatic organisms as it is often ingested with food or passed through gills.

The variability of sediment sampling for the <0.063mm fraction is shown below in Figure 3, which shows zinc concentrations over five sampling events from the former Kidston mine site. At WB, the upstream reference site, zinc concentrations fluctuated between 88 mg/kg to 188 mg/kg between successive sampling events (29/11/2014 and 28/05/2015). The 19/11/2013 sampling event appears to show higher concentrations than previous or successive events, while the 23/05/2013 event generally shows the second-highest levels of concentrations. These factors introduce a high degree of uncertainty when interpreting the results below in Figure 3.

Subsequently replication of sediment samples is required to more adequately detect the variability of sediment and metals at each site. Three replicates are proposed for each site of the <0.063mm fraction. However the initial sediment study will undertake 5x replicates at each site to characterise the nature of variability. The recommended number of replicates for ongoing monitoring will be provided as an outcome of the Initial Sediment Study.

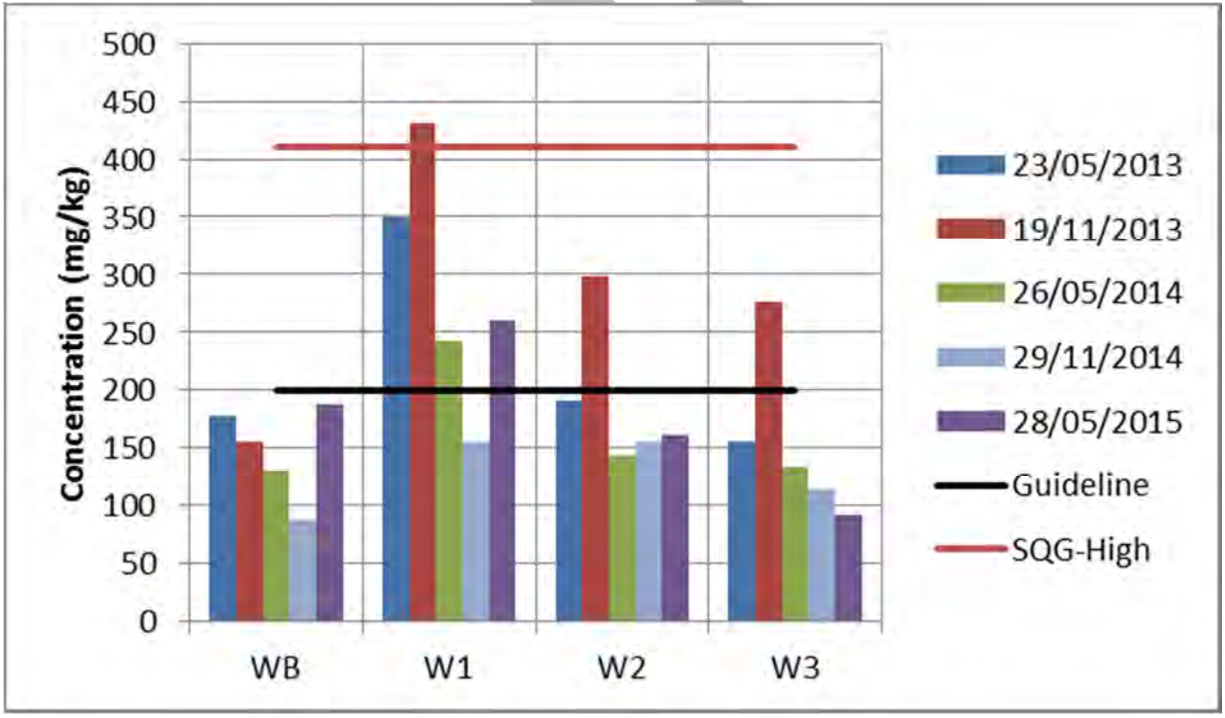

Figure 3 Results for zinc concentrations at monitoring sites form the former Kidston mine

5.3.3 Accumulation of Reference Site Data

The REMP recommends an initial sediment study (refer Section 4.2.1) be undertaken to quantify concentrations of parameters that are outlined in Table 7 in the receiving environment with sufficient replication to remove errors that may be present as a result of the inherent variability of targeted sediment sampling in a river system.

It is recommended that values from reference sites in the Copperfield River are accumulated over a number of years and used to calculate suitable statistics for comparison to impact sites. This will allow a measure of Before-After-Control-Impact (BACI) analysis as outlined in the ANZECC (2000) guidelines. In the case of ongoing sediment sampling, statistics from reference sites should contain preferably 15 replicates from each site. This is approximately 5 years' worth of data.

Statistics from impact sites, based on three replicate samples, will then be compared to the 15 replicates from the reference sites. The previous 15 replicates should always be chosen for the reference site, including the current sampling event.

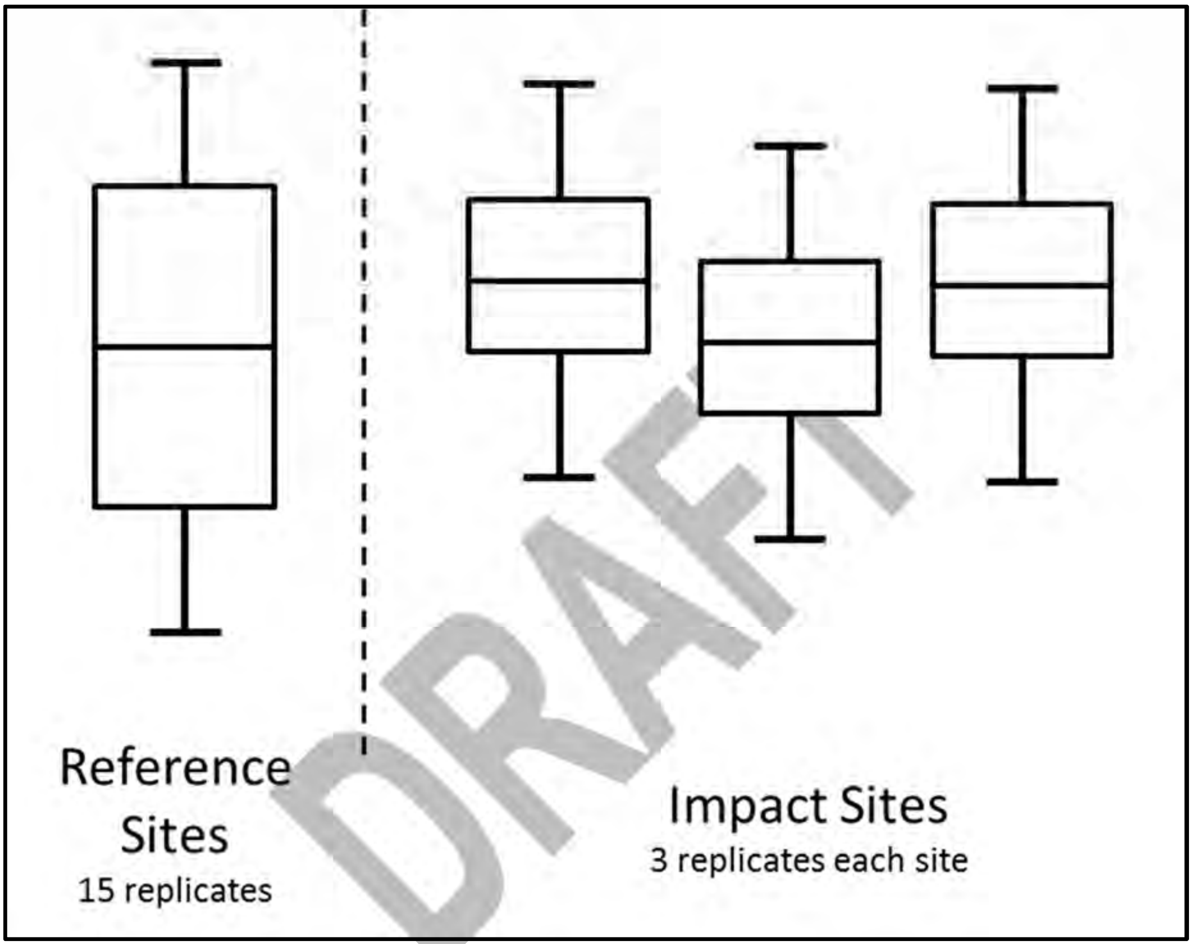

Figure 4 Example box plot comparison of multi-year reference site dataset to single-year impact site data.

5.3.4 Assessment against guideline values

As outlined in the ANZECC (2000) guidelines, a sediment trigger level or guideline is said to be exceeded when the 95th percentile of the dataset is above the trigger level or guideline value. Initially the sediment quality sample data is to be compared to the guidelines outlined in Table 4. If the sediment values exceed the trigger levels, then the data should be compared to upstream data.

The recommended approach is to calculate the median (background) concentration and multiply it by a certain factor (typically two) (Simpson, Graeme, & Chariton, 2013). This approach is applied to EAs of mine sites throughout Queensland and allows site-specific concentrations of the above contaminants to be provided.

Where replicate samples are taken at a monitoring site, an exceedance is taken to be where the 95th percentile of the replicate samples exceeds the guideline value as outlined in Table 4. Where the replicate samples from an impact site are compared to replicate samples from a reference site, an exceedance is taken to be where the 95th percentile of the impact site exceeds the maximum at the reference site.

5.4 Biological Monitoring

5.4.1.1 Aquatic Habitat

Aquatic habitat scores are to be compiled using methods outlined in the AusRivas Sampling Manual and an overall habitat score provided for each site. The overall habitat scores for all sites should be compared side by side to allow the relative condition of each site to be compared to all other sites.

Critical information that may affect the habitat score should be highlighted and discussed when interpreting the results.

5.4.1.2 Macroinvertebrates

Macroinvertebrate data is used to indicate ecosystem health in a number of indices. These indices are outlined below in Table 10. These indices will be used to compare upstream and downstream sites. Emphasis in reporting and analysis is to be placed on the difference between upstream and downstream sites and the factors contributing towards these differences rather than absolute values.

Table 10 Indices of environmental health based on macroinvertebrate data

Name	Description
Taxonomic Richness	Total number of families within a sample. Most unambiguous diversity measurements. However this is a presence / absence metric and the abundance is not incorporated. Subsequently rare taxa have the same weighting as common taxa. Typically healthier communities have greater diversity.
PET (Plecoptera, Ephemeroptera, Trichoptera) Taxa Richness	The number of taxa collected from stoneflies (Plecoptera), mayflies (Ephemeroptera) and caddisflies (Trichoptera) which are sensitive to environmental change. There are typically more PET families in sites with good habitat and water quality than in heavily impacted sites. PET taxa are often the first to disappear when water quality or environmental degradation occurs. Lower scores of PET taxa indicate higher values of degradation.
SIGNAL 2 Index (Stream Invertebrate Grade Number – Average Level)	SIGNAL 2 scores are a measure of the sensitivity of freshwater macroinvertebrate families to pollutants and other physical and chemical stressors. SIGNAL 2 scores consider the relative abundance of tolerant or sensitive taxa, rather than just the presence/absence of these families. Low SIGNAL 2 scores indicate poor habitat quality and/or impact, as a low value represents a high abundance of taxa tolerant to environmental change and a low abundance of taxa which are intolerant to environmental change. A high SIGNAL 2 score indicates a moderate to high abundance of taxa which are intolerant to environmental change, indicating good habitat quality. The SIGNAL 2 score also considers background assessments for the region or specific stream boundaries. There have been no such studies undertaken for the Gilbert River catchment and the SIGNAL 2 scores should adopt interim boundaries based on the Central Queensland guidelines for indicative comparison (C&R Consulting, 2018).

Multivariate Analysis

Quantitative macroinvertebrate analysis allows multivariate analysis to be undertaken and provide an indication of the relationship between upstream and downstream sample sites for a number of parameters. This multivariate analysis is widely undertaken in the ecology field. Table 11 provides a brief description of the multivariate analyses to perform for the assessment.

Table 11 Multivariate analyses for macroinvertebrate data

Name	Description
SIMPER	Determines which variables (i.e. composition of macroinvertebrates) contribute to dissimilarity between sites and may help to define potential 'indicator' species.
nMDS (non metric multidimensional scaling) and associated Ordination Plots	A graph where the proximity of data from each site to other sites indicates the similarities in macroinvertebrate. The graph is calculated from the Bray-Curtis similarity matrix which is calculated as part of the analysis.
ANOSIM	Compares the observed differences between groups with the differences amongst replicates within the groups. A global analysis is calculated to determine if there are differences between any of the samples. If there are differences, then comparisons between each combination of sites are undertaken. The results are indicated by an R statistic, whereby: • R > 0.75 = groups well separated • R > 0.50 = groups overlapping but clearly different • R < 0.25 = groups barely separated • Significance Level <5% = significant difference
RELATE (including BioEnv)	Used to correlate water, sediment and macroinvertebrate data to determine which water and sediment parameters are having the most impact.

It is recommended that the above analyses are undertaken in the PRIMER software package. This package has been developed specifically to undertake the above analyses and will provide consistent graphical outputs from year to year to allow easy comparison of data.

Comparison

For macroinvertebrate data, analysis results from upstream sites are to be compared to downstream sites to determine if there is any discernible difference. If there are no differences that are not attributable to other environmental factors (such as the percentage of macrophyte cover between sites), then an impact can have been said to occur.

5.5 Groundwater

Groundwater data should be analysed to determine if there are any correlations between pit water data and the receiving environment. This will involve examination of correlations between certain parameters (i.e. zinc) as well as examination of cation/anion compositions. Groundwater quality data are to be compared to trigger levels outlined in Table 2, but exceedances of groundwater quality samples with the trigger values in Table 2 should not trigger investigation. The purpose of groundwater monitoring is to identify any linkages between the pit water and the Copperfield River. The WQOs outlined in Table 2 were developed for surface water systems and are not meant to be applied to groundwater systems. The WQOs outlined in Table 2 are appropriate for SW quality and will not be used as GW trigger values; however, the WQOs will be used for comparison with GW water sampled from bores BA06 and BA07 to evaluate long-term trends in GW quality, which will aid in assessment of potential linkages between the pit water and the Copperfield River.

6.0 Reporting and Review

All data collected as part of the REMP must be compiled into an annual REMP Assessment Report by October each year. The report must include:

- An overview of the releases for that period, including start date/time, end date/time and the volume released.
- A description of monitoring undertaken for all parameters outlined in this report.
- Examination of the suitability of data for derivation of local WQOs. If data is suitable, derive local WQOs using data collected as part of the REMP.
- Comparison of data collected in this report to licence conditions, standards, WQOs and include upstream to downstream comparison.
- An assessment by the author on the likelihood of environmental harm occurring as a result of the release regime.
- A review of the suitability of monitoring locations, methods, timing, frequencies and parameters.
- Provide a summary table of monitoring required for the next REMP period.

The outcomes of the REMP should be used to evaluate whether Mitigation Measures need to be applied as outlined in the IAR.

7.0 References

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Appendix A

REMP Monitoring Locations and Frequencies

D R A F T

Appendix A REMP Monitoring Locations and Frequencies

Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	Sediment Quality	Biological	Flow
Regional Monitoring – Background Sites	WB	201087	7907273	Upstream of all influences on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	Pond 3	200868	7907862	Pool situated 1.4km upstream				
	E1	203774	7912124	East Creek upstream of the confluence with the Copperfield River				
Regional Monitoring – Impact Sites	W1	200799	7908133	Downstream of the Tailings Storage Facility on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	W2	201851	7910299	Downstream of Manager's Creek Dam on the Copperfield River				
	W3	202667	7915973	At the causeway entrance to the Kidston Project on the Copperfield River. Most downstream monitoring point.				
	E2	202887	7912971	East Creek downstream of the confluence with the Copperfield River			N/A	
	Pond 5	202761	7915578	Pool situated 7.0km downstream		N/A	N/A	
	Copperfield River at the confluence with Sandy Creek (waterhole)	197509	7929897	Pool situated 20km downstream		N/A	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	
	EG1	TBA[1]	TBA[1]	Einasleigh Gorge		**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] At the end of the Wet Season after releases have ceased	N/A	
Near-field monitoring - Mixing Zone	US1	TBA[#]	TBA[#]	Immediately upstream of release location	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	N/A	Continuous
	DS1	TBA[#]	TBA[#]	Immediately downstream of mixing zone for releases from the K2H Project			N/A	Continuous

Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	Sediment Quality	Biological	Flow
Release Water	Eldridge Pit	TBA[#]	TBA[#]	Eldridge Pit at the Ramp	**Baseline Monitoring** • Monthly for the first 24 months of Operation • Quarterly thereafter	N/A	N/A	N/A
	Wises Pit	TBA[#]	TBA[#]	Wises Pit at the Ramp				N/A
	Release Water	TBA[#]	TBA[#]	Sample of waters at the Release Point into the Copperfield River	• Within 24 hours of commencement of release • Every day thereafter while releases are occurring.			N/A
Groundwater Monitoring	BA06	201067	7909160	6.0m deep well installed in river loam and sand.	**Construction Phase** • Monthly **Operational Phase** • Quarterly	N/A	N/A	**WATER LEVEL:** **Construction Phase** • Monthly **Operational Phase** • Monthly
	BA07	201595	7910262	5.0m deep well installed in river loam and sand.				

[1] The most suitable location for monitoring at the Einasleigh Gorge to be defined prior to the first release. Location is to be suitable for access in wet-weather events and suitable for water quality monitoring. NOTE: the sediment monitoring location may be different than the water quality sampling location as it would be ideal to capture sediment just upstream of the gorge in the dry river bed

[#] Location to be determined after installation of appropriate infrastructure.

[2] The initial sediment study is to determine whether replicates are required at each site for ongoing monitoring.

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000

metres

1:30,000 (when printed at A3)

AECOM

www.aecom.com

Legend

- ● Groundwater Bore
- ● Monitoring Point
- ● Proposed RP
- ● Release Point
- — Watercourse - Major
- — Watercourse - Minor

Location of Monitoring Points for the K2H REMP

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	FraserR2l - 08 Jan 2019
VERSION:	2

Figure

A3 size

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\04_Outgoing\20190108_RF_K2H_MPs\20190108_RF_K2H_MPs.mxd

Appendix D

Certificates of Analysis

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	ARRAN MCGHIE	Manager	Jon Dicker
Client	GENEX POWER	Laboratory	SGS Cairns Environmental
Address	GPO BOX 4626 SYDNEY NSW 2000	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	61 2 90488854	Telephone	+61 07 4035 5111
Facsimile	(Not specified)	Facsimile	+61 07 4035 5122
Email	am@genexpower.com.au	Email	AU.Environmental.Cairns@sgs.com
Project	**60544566 - Kidston K2H**	SGS Reference	**CE138103 R0**
Order Number	**COD**	Date Received	14 Feb 2019
Samples	15	Date Reported	26 Feb 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

			Sample Number	CE138103.001	CE138103.002	CE138103.003	CE138103.004
			Sample Matrix	Water	Water	Water	Water
			Sample Date	11 Feb 2019	11 Feb 2019	11 Feb 2019	11 Feb 2019
			Sample Name	WB 11/2	W1 11/2	W2 11/2	W3 11/2
Parameter	Units	LOR					

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 14/2/2019

Conductivity @ 25 C	µS/cm	2	**82**	**67**	**1600**	**70**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 14/2/2019

Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	**0.017**	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 19/2/2019

Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.016**	**0.016**	**0.69**	**0.031**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.015**	**0.015**	**0.69**	**0.030**

Nitrite in Water Method: AN277 Tested: 15/2/2019

Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	**0.007**	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Total Kjeldahl Nitrogen	mg/L	0.05	**0.80**	**0.34**	**0.43**	**0.25**
Total Nitrogen (calc)	mg/L	0.05	**0.82**	**0.35**	**1.1**	**0.28**
Organic Nitrogen (calc)	mg/L	0.05	**0.80**	**0.32**	**0.43**	**0.25**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.06**	**0.05**	**0.04**	**0.05**

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE138103.001 Water 11 Feb 2019 WB 11/2	CE138103.002 Water 11 Feb 2019 W1 11/2	CE138103.003 Water 11 Feb 2019 W2 11/2	CE138103.004 Water 11 Feb 2019 W3 11/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 15/2/2019							
Filterable Reactive Phosphorus as P	mg/L	0.005		**0.006**	**0.009**	**0.011**	**0.014**

		Sample Number	CE138103.005	CE138103.006	CE138103.007	CE138103.008
		Sample Matrix	Water	Water	Water	Water
		Sample Date	11 Feb 2019	12 Feb 2019	12 Feb 2019	12 Feb 2019
		Sample Name	CG 11/2	WB 12/2	W1 12/2	W2 12/2
Parameter	**Units**	**LOR**				
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 14/2/2019						
Conductivity @ 25 C	µS/cm	2	**77**	**94**	**69**	**73**
Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 14/2/2019						
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005
Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 19/2/2019						
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.044**	**0.013**	**0.038**	**0.053**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.042**	**0.013**	**0.037**	**0.052**
Nitrite in Water Method: AN277 Tested: 15/2/2019						
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005
TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019						
Total Kjeldahl Nitrogen	mg/L	0.05	**0.21**	**0.28**	**0.33**	**0.24**
Total Nitrogen (calc)	mg/L	0.05	**0.25**	**0.30**	**0.37**	**0.29**
Organic Nitrogen (calc)	mg/L	0.05	**0.21**	**0.28**	**0.33**	**0.24**
Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019						
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.04**	**0.03**	**0.04**	**0.04**

Parameter	Units	LOR	CE138103.005	CE138103.006	CE138103.007	CE138103.008
Sample Matrix			Water	Water	Water	Water
Sample Date			11 Feb 2019	12 Feb 2019	12 Feb 2019	12 Feb 2019
Sample Name			CG 11/2	WB 12/2	W1 12/2	W2 12/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 15/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.016**	**0.008**	**0.013**	**0.019**

		Sample Number	CE138103.009	CE138103.010	CE138103.011	CE138103.012
		Sample Matrix	Water	Water	Water	Water
		Sample Date	12 Feb 2019	12 Feb 2019	13 Feb 2019	13 Feb 2019
		Sample Name	W3 12/2	CG 12/2	WB 13/2	W1 13/2
Parameter	Units	LOR				

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 14/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Conductivity @ 25 C	µS/cm	2	**71**	**78**	**75**	**70**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 14/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 19/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.048**	**0.057**	**0.025**	**0.010**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.046**	**0.056**	**0.025**	**0.009**

Nitrite in Water Method: AN277 Tested: 15/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Total Kjeldahl Nitrogen	mg/L	0.05	**0.28**	**0.29**	**0.28**	**0.22**
Total Nitrogen (calc)	mg/L	0.05	**0.33**	**0.35**	**0.31**	**0.23**
Organic Nitrogen (calc)	mg/L	0.05	**0.28**	**0.29**	**0.28**	**0.22**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.05**	**0.05**	<0.02	<0.02

Parameter	Units	LOR	CE138103.009	CE138103.010	CE138103.011	CE138103.012
Sample Matrix			Water	Water	Water	Water
Sample Date			12 Feb 2019	12 Feb 2019	13 Feb 2019	13 Feb 2019
Sample Name			W3 12/2	CG 12/2	WB 13/2	W1 13/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 15/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.015**	**0.014**	**0.006**	**0.012**

		Sample Number	CE138103.013	CE138103.014	CE138103.015
		Sample Matrix	Water	Water	Water
		Sample Date	13 Feb 2019	13 Feb 2019	13 Feb 2019
		Sample Name	W2 13/2	W3 13/2	CG 13/2
Parameter	Units	LOR			

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 14/2/2019

Conductivity @ 25 C	µS/cm	2	**82**	**73**	**83**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 14/2/2019

Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 19/2/2019

Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.017**	**0.018**	**0.023**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.016**	**0.017**	**0.022**

Nitrite in Water Method: AN277 Tested: 15/2/2019

Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Total Kjeldahl Nitrogen	mg/L	0.05	**0.18**	**0.26**	**0.18**
Total Nitrogen (calc)	mg/L	0.05	**0.20**	**0.28**	**0.21**
Organic Nitrogen (calc)	mg/L	0.05	**0.18**	**0.26**	**0.18**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	<0.02	<0.02	<0.02

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE138103.013 Water 13 Feb 2019 W2 13/2	CE138103.014 Water 13 Feb 2019 W3 13/2	CE138103.015 Water 13 Feb 2019 CG 13/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 15/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005		**0.012**	**0.011**	**0.012**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by Discrete Analyser Method: ME-(AU)-[ENV]AN280

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ammonia Nitrogen, NH3 as N	LB064467	mg/L	0.005	<0.005	0%	97%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB064441	µS/cm	2	<2	0 - 1%	106%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Filterable Reactive Phosphorus as P	LB064541	mg/L	0.005	<0.005	0 - 2%	90 - 101%

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB064626	mg/L	0.005	<0.005	0 - 9%	106 - 107%

Nitrite in Water Method: ME-(AU)-[ENV]AN277

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrite Nitrogen, NO2 as N	LB064536	mg/L	0.005	<0.005	0 - 7%	108 - 111%

TKN Kjeldahl Digestion by Discrete Analyser Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB064589	mg/L	0.05	<0.05	7 - 12%	97 - 99%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Water **Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB064589	mg/L	0.02	<0.02	4%	95 - 107%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN248	Nitrate / Nitrite by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.
AN277/WC250.312	Nitrite ions, when reacted with a reagent containing sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride produce a highly coloured azo dye that is measured photometrically at 540nm.
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293(Sydney)	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN280	A filtered water sample containing ammonia (NH3) or ammonium cations (NH4+) is reacted with alkaline phenol and hypochlorite in a buffered solution to form the blue indophenol colour . The absorbance is measured at 630nm and compared with calibration standards to obtain the concentration of ammonia in the sample.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Aquakem 250 Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH, and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	ARRAN MCGHIE
Client	GENEX POWER
Address	GPO BOX 4626 SYDNEY NSW 2000
Telephone	61 2 90488854
Facsimile	(Not specified)
Email	am@genexpower.com.au
Project	**60544566 - Kidston K2H**
Order Number	**COD**
Samples	14

LABORATORY DETAILS

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SGS Reference	**CE138148 R0**
Date Received	18 Feb 2019
Date Reported	22 Feb 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

		Sample Number	CE138148.001	CE138148.002	CE138148.003	CE138148.004
		Sample Matrix	Water	Water	Water	Water
		Sample Date	14 Feb 2019	14 Feb 2019	14 Feb 2019	14 Feb 2019
		Sample Name	WB 14/2	W1 14/2	W2 14/2	CG 14/2
Parameter	Units	LOR				

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Conductivity @ 25 C	µS/cm	2	**160**	**74**	**88**	**81**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.007**	<0.005	**0.009**	**0.008**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.007**	<0.005	**0.008**	**0.007**

Nitrite in Water Method: AN277 Tested: 19/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Total Kjeldahl Nitrogen	mg/L	0.05	**0.53**	**0.39**	**0.35**	**0.28**
Total Nitrogen (calc)	mg/L	0.05	**0.54**	**0.39**	**0.36**	**0.29**
Organic Nitrogen (calc)	mg/L	0.05	**0.53**	**0.39**	**0.35**	**0.28**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Parameter	Units	LOR	CE138148.001	CE138148.002	CE138148.003	CE138148.004
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.05**	**0.03**	**0.03**	**0.04**

		Sample Number	CE138148.001	CE138148.002	CE138148.003	CE138148.004
		Sample Matrix	Water	Water	Water	Water
		Sample Date	14 Feb 2019	14 Feb 2019	14 Feb 2019	14 Feb 2019
		Sample Name	WB 14/2	W1 14/2	W2 14/2	CG 14/2
Parameter	**Units**	**LOR**				
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	<0.005	**0.007**	**0.008**	**0.010**

		Sample Number	CE138148.005	CE138148.006	CE138148.007	CE138148.008
		Sample Matrix	Water	Water	Water	Water
		Sample Date	15 Feb 2019	15 Feb 2019	15 Feb 2019	15 Feb 2019
		Sample Name	WB 15/2	W1 15/2	W2 15/2	W3 15/2
Parameter	Units	LOR				
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/2/2019						
Conductivity @ 25 C	µS/cm	2	**140**	**73**	**100**	**77**
Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 18/2/2019						
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	**0.006**
Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019						
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.008**	<0.005	**0.009**	**0.010**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.008**	<0.005	**0.008**	**0.008**
Nitrite in Water Method: AN277 Tested: 19/2/2019						
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005
TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019						
Total Kjeldahl Nitrogen	mg/L	0.05	**0.40**	**0.26**	**0.33**	**0.51**
Total Nitrogen (calc)	mg/L	0.05	**0.41**	**0.26**	**0.34**	**0.52**
Organic Nitrogen (calc)	mg/L	0.05	**0.40**	**0.26**	**0.33**	**0.50**
Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019						
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.04**	**0.03**	**0.03**	**0.03**

		Sample Number	CE138148.005	CE138148.006	CE138148.007	CE138148.008
		Sample Matrix	Water	Water	Water	Water
		Sample Date	15 Feb 2019	15 Feb 2019	15 Feb 2019	15 Feb 2019
		Sample Name	WB 15/2	W1 15/2	W2 15/2	W3 15/2
Parameter	**Units**	**LOR**				
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.006**	**0.008**	**0.008**	**0.007**

Parameter	Units	LOR				
		Sample Number	CE138148.009	CE138148.010	CE138148.011	CE138148.012
		Sample Matrix	Water	Water	Water	Water
		Sample Date	15 Feb 2019	13 Feb 2019	13 Feb 2019	13 Feb 2019
		Sample Name	CG 15/2	WB 13/2	W1 13/2	W2 13/2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Conductivity @ 25 C	µS/cm	2	**150**	**130**	**72**	**86**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	<0.005	**0.005**	**0.007**	**0.007**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	<0.005	<0.005	**0.006**	**0.006**

Nitrite in Water Method: AN277 Tested: 19/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Total Kjeldahl Nitrogen	mg/L	0.05	**0.19**	**0.45**	**0.41**	**0.33**
Total Nitrogen (calc)	mg/L	0.05	**0.19**	**0.46**	**0.42**	**0.34**
Organic Nitrogen (calc)	mg/L	0.05	**0.19**	**0.45**	**0.41**	**0.33**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Parameter	Units	LOR	CE138148.009	CE138148.010	CE138148.011	CE138148.012
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.03**	**0.04**	**0.04**	**0.04**

Parameter	Units	LOR	Sample Number: CE138148.009 Sample Matrix: Water Sample Date: 15 Feb 2019 Sample Name: CG 15/2	CE138148.010 Water 13 Feb 2019 WB 13/2	CE138148.011 Water 13 Feb 2019 W1 13/2	CE138148.012 Water 13 Feb 2019 W2 13/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.011**	<0.005	**0.008**	**0.009**

		Sample Number	CE138148.013	CE138148.014
		Sample Matrix	Water	Water
		Sample Date	13 Feb 2019	13 Feb 2019
		Sample Name	W3 13/2	CG 13/2
Parameter	Units	LOR		

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/2/2019

Conductivity @ 25 C	µS/cm	2	**75**	**100**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 18/2/2019

Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.005**	**0.015**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	<0.005	**0.013**

Nitrite in Water Method: AN277 Tested: 19/2/2019

Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 18/2/2019

Total Kjeldahl Nitrogen	mg/L	0.05	**0.78**	**0.29**
Total Nitrogen (calc)	mg/L	0.05	**0.78**	**0.30**
Organic Nitrogen (calc)	mg/L	0.05	**0.77**	**0.29**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 18/2/2019

Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.03**	**0.04**

		Sample Number	CE138148.013	CE138148.014
		Sample Matrix	Water	Water
		Sample Date	13 Feb 2019	13 Feb 2019
		Sample Name	W3 13/2	CG 13/2
Parameter	Units	LOR		
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019				
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.006**	**0.011**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by Discrete Analyser Method: ME-(AU)-[ENV]AN280

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ammonia Nitrogen, NH3 as N	LB064605	mg/L	0.005	<0.005	0%	97%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB064580	µS/cm	2	<2	0 - 1%	102%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Filterable Reactive Phosphorus as P	LB064677	mg/L	0.005	<0.005	0 - 4%	91 - 92%

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB064628	mg/L	0.005	<0.005	0 - 46%	102 - 103%

Nitrite in Water Method: ME-(AU)-[ENV]AN277

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrite Nitrogen, NO2 as N	LB064640	mg/L	0.005	<0.005	0%	93 - 95%

TKN Kjeldahl Digestion by Discrete Analyser Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB064592	mg/L	0.05	<0.05	8%	96 - 111%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Water **Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB064592	mg/L	0.02	<0.02	9%	99 - 103%

METHOD	METHODOLOGY SUMMARY
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN248	Nitrate / Nitrite by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.
AN277/WC250.312	Nitrite ions, when reacted with a reagent containing sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride produce a highly coloured azo dye that is measured photometrically at 540nm.
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
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FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:
a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

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Project	**60544566 - Kidston K2H**
Order Number	**COD**
Samples	11

LABORATORY DETAILS

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SGS Reference	**CE138161 R0**
Date Received	18 Feb 2019
Date Reported	26 Feb 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

SIGNATORIES

Anthony Nilsson	Jon Dicker
Operations Manager	Manager Northern QLD

Parameter	Units	LOR				
		Sample Number	CE138161.001	CE138161.002	CE138161.003	CE138161.004
		Sample Matrix	Water	Water	Water	Water
		Sample Date	16 Feb 2019	16 Feb 2019	16 Feb 2019	16 Feb 2019
		Sample Name	WB 16/2	W1 16/2	W2 16/2	W3 16/2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 19/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Conductivity @ 25 C	µS/cm	2	**130**	**76**	**99**	**80**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 26/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	**0.011**	**0.008**	**0.007**	**0.008**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	**0.011**	**0.008**	**0.007**	**0.008**

Nitrite in Water Method: AN277 Tested: 25/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 21/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Total Kjeldahl Nitrogen	mg/L	0.05	**0.27**	**0.20**	**0.24**	**0.26**
Total Nitrogen (calc)	mg/L	0.05	**0.28**	**0.20**	**0.25**	**0.27**
Organic Nitrogen (calc)	mg/L	0.05	**0.26**	**0.19**	**0.24**	**0.26**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 21/2/2019

Parameter	Units	LOR	WB 16/2	W1 16/2	W2 16/2	W3 16/2
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.05**	**0.05**	**0.04**	**0.04**

Parameter	Units	LOR	CE138161.001 Water 16 Feb 2019 WB 16/2	CE138161.002 Water 16 Feb 2019 W1 16/2	CE138161.003 Water 16 Feb 2019 W2 16/2	CE138161.004 Water 16 Feb 2019 W3 16/2
Sample Number / Sample Matrix / Sample Date / Sample Name						
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.005**	**0.005**	**0.007**	**0.006**

		Sample Number	CE138161.005	CE138161.006	CE138161.007	CE138161.008
		Sample Matrix	Water	Water	Water	Water
		Sample Date	16 Feb 2019	17 Feb 2019	17 Feb 2019	17 Feb 2019
		Sample Name	CG 16/2	WB 17/2	W1 17/2	W2 17/2
Parameter	Units	LOR				
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 19/2/2019						
Conductivity @ 25 C	µS/cm	2	**84**	**220**	**79**	**220**
Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 26/2/2019						
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	**0.080**	<0.005	<0.005
Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019						
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	<0.005	**0.014**	<0.005	<0.005
Nitrate Nitrogen, NO3 as N	mg/L	0.005	<0.005	**0.014**	<0.005	<0.005
Nitrite in Water Method: AN277 Tested: 25/2/2019						
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005
TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 21/2/2019						
Total Kjeldahl Nitrogen	mg/L	0.05	**0.22**	**0.80**	**0.24**	**0.16**
Total Nitrogen (calc)	mg/L	0.05	**0.22**	**0.81**	**0.24**	**0.16**
Organic Nitrogen (calc)	mg/L	0.05	**0.22**	**0.72**	**0.24**	**0.16**
Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 21/2/2019						
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.04**	**0.08**	**0.03**	**0.04**

Parameter	Units	LOR	CE138161.005	CE138161.006	CE138161.007	CE138161.008
Sample Matrix			Water	Water	Water	Water
Sample Date			16 Feb 2019	17 Feb 2019	17 Feb 2019	17 Feb 2019
Sample Name			CG 16/2	WB 17/2	W1 17/2	W2 17/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005	**0.009**	<0.005	**0.007**	**0.006**

		Sample Number	CE138161.009	CE138161.010	CE138161.011
		Sample Matrix	Water	Water	Water
		Sample Date	17 Feb 2019	17 Feb 2019	15 Feb 2019
		Sample Name	W3 17/2	CG 17/2	W3 15/2
Parameter	Units	LOR			

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 19/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Conductivity @ 25 C	µS/cm	2	**82**	**86**	**79**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 26/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	**0.007**	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	<0.005	<0.005	**0.005**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	<0.005	<0.005	<0.005

Nitrite in Water Method: AN277 Tested: 25/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 21/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Total Kjeldahl Nitrogen	mg/L	0.05	**0.15**	**0.19**	**0.14**
Total Nitrogen (calc)	mg/L	0.05	**0.15**	**0.19**	**0.15**
Organic Nitrogen (calc)	mg/L	0.05	**0.14**	**0.18**	**0.14**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 21/2/2019

Parameter	Units	LOR	CE138161.009	CE138161.010	CE138161.011
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.02**	**0.03**	**0.04**

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE138161.009 Water 17 Feb 2019 W3 17/2	CE138161.010 Water 17 Feb 2019 CG 17/2	CE138161.011 Water 15 Feb 2019 W3 15/2
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/2/2019						
Filterable Reactive Phosphorus as P	mg/L	0.005		**0.007**	**0.006**	**0.008**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by Discrete Analyser Method: ME-(AU)-[ENV]AN280

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ammonia Nitrogen, NH3 as N	LB064881	mg/L	0.005	<0.005	0%	93%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB064617	µS/cm	2	<2	0 - 2%	101 - 102%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Filterable Reactive Phosphorus as P	LB064677	mg/L	0.005	<0.005	0 - 4%	91 - 92%

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB064628	mg/L	0.005	<0.005	0 - 46%	102 - 103%

Nitrite in Water Method: ME-(AU)-[ENV]AN277

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrite Nitrogen, NO2 as N	LB064813	mg/L	0.005	<0.005	0 - 2%	106 - 110%

TKN Kjeldahl Digestion by Discrete Analyser Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB064699	mg/L	0.05	<0.05	9%	98 - 104%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Water **Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB064699	mg/L	0.02	<0.02	32%	95 - 98%

METHOD	METHODOLOGY SUMMARY
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as μmhos/cm or μS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN248	Nitrate / Nitrite by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.
AN277/WC250.312	Nitrite ions, when reacted with a reagent containing sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride produce a highly coloured azo dye that is measured photometrically at 540nm.
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293(Sydney)	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN280	A filtered water sample containing ammonia (NH3) or ammonium cations (NH4+) is reacted with alkaline phenol and hypochlorite in a buffered solution to form the blue indophenol colour . The absorbance is measured at 630nm and compared with calibration standards to obtain the concentration of ammonia in the sample.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Aquakem 250 Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH , and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
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Project	**60544566 - Kidston K2H**	SGS Reference	**CE138238 R0**
Order Number	**COD**	Date Received	20 Feb 2019
Samples	5	Date Reported	26 Feb 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

SIGNATORIES

Anthony Nilsson Operations Manager	Jon Dicker Manager Northern QLD	Maristela Ganzan Metals Team Leader

		Sample Number	CE138238.001	CE138238.002	CE138238.003	CE138238.004
		Sample Matrix	Water	Water	Water	Water
		Sample Date	19 Feb 2019	19 Feb 2019	19 Feb 2019	19 Feb 2019
		Sample Name	WB	W1	W2	W3
Parameter	Units	LOR				

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 21/2/2019

Conductivity @ 25 C	µS/cm	2	**90**	**78**	**81**	**77**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 22/2/2019

Ammonia Nitrogen, NH3 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 21/2/2019

Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	<0.005	**0.005**	**0.008**	**0.007**
Nitrate Nitrogen, NO3 as N	mg/L	0.005	<0.005	<0.005	**0.007**	**0.006**

Nitrite in Water Method: AN277 Tested: 25/2/2019

Nitrite Nitrogen, NO2 as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 22/2/2019

Total Kjeldahl Nitrogen	mg/L	0.05	**0.24**	**0.43**	**0.32**	**0.35**
Total Nitrogen (calc)	mg/L	0.05	**0.24**	**0.44**	**0.32**	**0.36**
Organic Nitrogen (calc)	mg/L	0.05	**0.24**	**0.43**	**0.31**	**0.35**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 22/2/2019

Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	<0.02	<0.02	<0.02	<0.02

		Sample Number Sample Matrix Sample Date Sample Name	CE138238.001 Water 19 Feb 2019 WB	CE138238.002 Water 19 Feb 2019 W1	CE138238.003 Water 19 Feb 2019 W2	CE138238.004 Water 19 Feb 2019 W3
Parameter	Units	LOR				

Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 25/2/2019

Filterable Reactive Phosphorus as P	mg/L	0.005	**0.005**	**0.007**	**0.007**	**0.007**

pH in water Method: AN101 Tested: 21/2/2019

pH**	pH Units	0.1	-	-	-	-

Alkalinity Method: AN135 Tested: 21/2/2019

Total Alkalinity as CaCO3	mg/L	5	-	-	-	-
Bicarbonate Alkalinity as CaCO3	mg/L	5	-	-	-	-
Carbonate Alkalinity as CaCO3	mg/L	5	-	-	-	-
Hydroxide Alkalinity as CaCO3	mg/L	5	-	-	-	-

Acidity and Free CO2 Method: AN140 Tested: 26/2/2019

Acidity to pH 8.3	mg CaCO3/L	5	-	-	-	-

Total Dissolved Solids (TDS) in water Method: AN113 Tested: 26/2/2019

Total Dissolved Solids Dried at 175-185°C	mg/L	10	-	-	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 26/2/2019

Chloride, Cl	mg/L	1	-	-	-	-

		Sample Number	CE138238.001	CE138238.002	CE138238.003	CE138238.004
		Sample Matrix	Water	Water	Water	Water
		Sample Date	19 Feb 2019	19 Feb 2019	19 Feb 2019	19 Feb 2019
		Sample Name	WB	W1	W2	W3
Parameter	Units	LOR				

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 21/2/2019

Fluoride by ISE	mg/L	0.05	-	-	-	-

Metals in Water (Total) by ICPOES Method: AN022/AN320 Tested: 25/2/2019

Total Aluminium	mg/L	0.005	-	-	-	-
Total Barium	mg/L	0.005	-	-	-	-
Total Boron	mg/L	0.005	-	-	-	-
Total Calcium	mg/L	0.05	-	-	-	-
Total Iron	mg/L	0.02	-	-	-	-
Total Magnesium	mg/L	0.05	-	-	-	-
Total Manganese	mg/L	0.005	-	-	-	-
Total Potassium	mg/L	0.05	-	-	-	-
Total Sodium	mg/L	0.5	-	-	-	-
Total Sulphur as Sulfate, SO4	mg/L	0.5	-	-	-	-
Total Vanadium	mg/L	0.01	-	-	-	-
Total Zinc	mg/L	0.005	-	-	-	-
Total Hardness*	mg CaCO3/L	5	-	-	-	-

Calculation of Anion-Cation Balance (SAR Calc) Method: AN121 Tested: 26/2/2019

Sum of Cation Milliequivalents*	meq/L	-	-	-	-	-
Sum of Anion Milliequivalents*	meq/L	-	-	-	-	-
Anion-Cation Balance	%	-100	-	-	-	-

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/2/2019

Aluminium, Al	mg/L	0.005	-	-	-	-
Barium, Ba	mg/L	0.005	-	-	-	-
Boron, B	mg/L	0.005	-	-	-	-
Iron, Fe	mg/L	0.005	-	-	-	-
Manganese, Mn	mg/L	0.005	-	-	-	-
Zinc, Zn	mg/L	0.005	-	-	-	-

Metals in Water (Dissolved) by ICPOES-USN Method: AN320/AN322 Tested: 25/2/2019

Arsenic, As	mg/L	0.003	-	-	-	-
Beryllium, Be	mg/L	0.0001	-	-	-	-
Cadmium, Cd	mg/L	0.0001	-	-	-	-
Chromium, Cr	mg/L	0.001	-	-	-	-
Cobalt, Co	mg/L	0.001	-	-	-	-
Copper, Cu	mg/L	0.001	-	-	-	-
Lead, Pb	mg/L	0.001	-	-	-	-
Molybdenum, Mo	mg/L	0.001	-	-	-	-
Nickel, Ni	mg/L	0.001	-	-	-	-
Selenium, Se	mg/L	0.003	-	-	-	-
Vanadium, V	mg/L	0.001	-	-	-	-

Trace Metals (Dissolved) in Water by ICPMS in mg/L Method: AN318 Tested: 26/2/2019

Uranium, U	mg/L	0.001	-	-	-	-

		Sample Number Sample Matrix Sample Date Sample Name	CE138238.001 Water 19 Feb 2019 WB	CE138238.002 Water 19 Feb 2019 W1	CE138238.003 Water 19 Feb 2019 W2	CE138238.004 Water 19 Feb 2019 W3
Parameter	Units	LOR				

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 22/2/2019

Parameter	Units	LOR	CE138238.001	CE138238.002	CE138238.003	CE138238.004
Mercury	mg/L	0.00005	-	-	-	-

Metals in Water (Total) by ICPOES-USN Method: AN320/AN322 Tested: 25/2/2019

Parameter	Units	LOR	CE138238.001	CE138238.002	CE138238.003	CE138238.004
Total Arsenic, As	mg/L	0.003	-	-	-	-
Total Beryllium, Be	mg/L	0.0001	-	-	-	-
Total Cadmium, Cd	mg/L	0.0001	-	-	-	-
Total Chromium, Cr	mg/L	0.001	-	-	-	-
Total Cobalt, Co	mg/L	0.001	-	-	-	-
Total Copper, Cu	mg/L	0.001	-	-	-	-
Total Lead, Pb	mg/L	0.001	-	-	-	-
Total Molybdenum, Mo	mg/L	0.001	-	-	-	-
Total Nickel, Ni	mg/L	0.001	-	-	-	-
Total Selenium, Se	mg/L	0.003	-	-	-	-

Trace Metals (Total) in Water by ICPMS in mg/L Method: AN318 Tested: 26/2/2019

Parameter	Units	LOR	CE138238.001	CE138238.002	CE138238.003	CE138238.004
Total Uranium	mg/L	0.001	-	-	-	-

Mercury (total) in Water Method: AN311(Perth) /AN312 Tested: 22/2/2019

Parameter	Units	LOR	CE138238.001	CE138238.002	CE138238.003	CE138238.004
Total Mercury	mg/L	0.00005	-	-	-	-

Sample Number	CE138238.005
Sample Matrix	Water
Sample Date	19 Feb 2019
Sample Name	Middle spring

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 21/2/2019

Parameter	Units	LOR	
Conductivity @ 25 C	µS/cm	2	**970**

Ammonia Nitrogen by Discrete Analyser Method: AN280 Tested: 22/2/2019

Parameter	Units	LOR	
Ammonia Nitrogen, NH3 as N	mg/L	0.005	**0.028**

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser Method: AN248 Tested: 22/2/2019

Parameter	Units	LOR	
Nitrate/Nitrite Nitrogen, NOx as N	mg/L	0.005	-
Nitrate Nitrogen, NO3 as N	mg/L	0.005	-

Nitrite in Water Method: AN277 Tested: 25/2/2019

Parameter	Units	LOR	
Nitrite Nitrogen, NO2 as N	mg/L	0.005	-

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 22/2/2019

Parameter	Units	LOR	
Total Kjeldahl Nitrogen	mg/L	0.05	-
Total Nitrogen (calc)	mg/L	0.05	-
Organic Nitrogen (calc)	mg/L	0.05	-

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 22/2/2019

Parameter	Units	LOR	
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	**0.07**

		Sample Number	CE138238.005
		Sample Matrix	Water
		Sample Date	19 Feb 2019
		Sample Name	Middle spring
Parameter	Units	LOR	

Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 26/2/2019

Filterable Reactive Phosphorus as P	mg/L	0.005	-

pH in water Method: AN101 Tested: 21/2/2019

pH**	pH Units	0.1	**7.8**

Alkalinity Method: AN135 Tested: 21/2/2019

Total Alkalinity as CaCO3	mg/L	5	**110**
Bicarbonate Alkalinity as CaCO3	mg/L	5	**110**
Carbonate Alkalinity as CaCO3	mg/L	5	<5
Hydroxide Alkalinity as CaCO3	mg/L	5	<5

Acidity and Free CO2 Method: AN140 Tested: 21/2/2019

Acidity to pH 8.3	mg CaCO3/L	5	<5

Total Dissolved Solids (TDS) in water Method: AN113 Tested: 25/2/2019

Total Dissolved Solids Dried at 175-185°C	mg/L	10	**640**

Chloride by Discrete Analyser in Water Method: AN274 Tested: 26/2/2019

Chloride, Cl	mg/L	1	**120**

		Sample Number	CE138238.005
		Sample Matrix	Water
		Sample Date	19 Feb 2019
		Sample Name	Middle spring
Parameter	Units	LOR	

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 21/2/2019

Fluoride by ISE	mg/L	0.05	**10**

Metals in Water (Total) by ICPOES Method: AN022/AN320 Tested: 25/2/2019

Total Aluminium	mg/L	0.005	**0.49**
Total Barium	mg/L	0.005	**0.095**
Total Boron	mg/L	0.005	**0.15**
Total Calcium	mg/L	0.05	**28**
Total Iron	mg/L	0.02	**0.59**
Total Magnesium	mg/L	0.05	**1.1**
Total Manganese	mg/L	0.005	**0.070**
Total Potassium	mg/L	0.05	**7.6**
Total Sodium	mg/L	0.5	**170**
Total Sulphur as Sulfate, SO4	mg/L	0.5	**140**
Total Vanadium	mg/L	0.01	<0.01
Total Zinc	mg/L	0.005	**0.008**
Total Hardness*	mg CaCO3/L	5	**74**

Calculation of Anion-Cation Balance (SAR Calc) Method: AN121 Tested: 26/2/2019

Sum of Cation Milliequivalents*	meq/L	-	**9.12**
Sum of Anion Milliequivalents*	meq/L	-	**8.57**
Anion-Cation Balance	%	-100	**3.1**

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/2/2019

Aluminium, Al	mg/L	0.005	**0.21**
Barium, Ba	mg/L	0.005	**0.088**
Boron, B	mg/L	0.005	**0.15**
Iron, Fe	mg/L	0.005	**0.34**
Manganese, Mn	mg/L	0.005	**0.043**
Zinc, Zn	mg/L	0.005	<0.005

		Sample Number	CE138238.005
		Sample Matrix	Water
		Sample Date	19 Feb 2019
		Sample Name	Middle spring
Parameter	Units	LOR	

Metals in Water (Dissolved) by ICPOES-USN Method: AN320/AN322 Tested: 25/2/2019

Arsenic, As	mg/L	0.003	<0.003
Beryllium, Be	mg/L	0.0001	<0.0001
Cadmium, Cd	mg/L	0.0001	<0.0001
Chromium, Cr	mg/L	0.001	<0.0010
Cobalt, Co	mg/L	0.001	<0.001
Copper, Cu	mg/L	0.001	<0.001
Lead, Pb	mg/L	0.001	**0.001**
Molybdenum, Mo	mg/L	0.001	**0.009**
Nickel, Ni	mg/L	0.001	**0.001**
Selenium, Se	mg/L	0.003	<0.003
Vanadium, V	mg/L	0.001	**0.003**

Trace Metals (Dissolved) in Water by ICPMS in mg/L Method: AN318 Tested: 21/2/2019

Uranium, U	mg/L	0.001	<0.001

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 22/2/2019

Mercury	mg/L	0.00005	<0.00005

Metals in Water (Total) by ICPOES-USN Method: AN320/AN322 Tested: 25/2/2019

Total Arsenic, As	mg/L	0.003	<0.003
Total Beryllium, Be	mg/L	0.0001	**0.0001**
Total Cadmium, Cd	mg/L	0.0001	<0.0001
Total Chromium, Cr	mg/L	0.001	**0.001**
Total Cobalt, Co	mg/L	0.001	<0.001
Total Copper, Cu	mg/L	0.001	<0.001
Total Lead, Pb	mg/L	0.001	**0.002**
Total Molybdenum, Mo	mg/L	0.001	**0.009**
Total Nickel, Ni	mg/L	0.001	**0.001**
Total Selenium, Se	mg/L	0.003	<0.003

Parameter	Units	LOR	Sample Number: CE138238.005 Sample Matrix: Water Sample Date: 19 Feb 2019 Sample Name: Middle spring

Trace Metals (Total) in Water by ICPMS in mg/L   Method: AN318   Tested: 21/2/2019

Total Uranium	mg/L	0.001	<0.001

Mercury (total) in Water   Method: AN311(Perth) /AN312   Tested: 22/2/2019

Total Mercury	mg/L	0.00005	<0.00005

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acidity and Free CO2 Method: ME-(AU)-[ENV]AN140

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Acidity to pH 8.3	LB064712	mg CaCO3/L	5	<5	100%

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB064689	mg/L	5	<5	2 - 3%	98 - 101%
Bicarbonate Alkalinity as CaCO3	LB064689	mg/L	5	<5		
Carbonate Alkalinity as CaCO3	LB064689	mg/L	5	<5		
Hydroxide Alkalinity as CaCO3	LB064689	mg/L	5	<5		

Ammonia Nitrogen by Discrete Analyser Method: ME-(AU)-[ENV]AN280

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ammonia Nitrogen, NH3 as N	LB064671	mg/L	0.005	<0.005	0 - 3%	95 - 97%

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride, Cl	LB064876	mg/L	1	<1	0 - 2%	99 - 100%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB064689	µS/cm	2	<2	0 - 5%	101 - 102%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Filterable Reactive Phosphorus as P	LB064826	mg/L	0.005	<0.005	3 - 11%	97%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB064689	mg/L	0.05	<0.05	1%	91 - 92%	90%

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB064761	mg/L	0.00005	<0.00005	0%	102 - 105%	120%

Mercury (total) in Water Method: ME-(AU)-[ENV]AN311(Perth) /AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Mercury	LB064762	mg/L	0.00005	<0.00005	0%	100%

Metals in Water (Total) by ICPOES Method: ME-(AU)-[ENV]AN022/AN320

Parameter	QC Reference	Units	LOR	LCS %Recovery
Total Aluminium	LB064800	mg/L	0.005	102%
Total Barium	LB064800	mg/L	0.005	101%
Total Boron	LB064800	mg/L	0.005	103%
Total Calcium	LB064800	mg/L	0.05	104%
Total Iron	LB064800	mg/L	0.02	103%
Total Magnesium	LB064800	mg/L	0.05	106%
Total Manganese	LB064800	mg/L	0.005	NA
Total Potassium	LB064800	mg/L	0.05	101%
Total Sodium	LB064800	mg/L	0.5	108%
Total Sulphur as Sulfate, SO4	LB064800	mg/L	0.5	102%
Total Vanadium	LB064800	mg/L	0.01	103%
Total Zinc	LB064800	mg/L	0.005	110%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Aluminium, Al	LB064799	mg/L	0.005	<0.005	103%
Barium, Ba	LB064799	mg/L	0.005	<0.005	101%
Boron, B	LB064799	mg/L	0.005	<0.005	103%
Iron, Fe	LB064799	mg/L	0.005	<0.005	104%
Manganese, Mn	LB064799	mg/L	0.005	<0.005	107%
Zinc, Zn	LB064799	mg/L	0.005	<0.005	111%

Metals in Water (Dissolved) by ICPOES-USN Method: ME-(AU)-[ENV]AN320/AN322

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Arsenic, As	LB064801	mg/L	0.003	<0.003	93%
Beryllium, Be	LB064801	mg/L	0.0001	<0.0001	105%
Cadmium, Cd	LB064801	mg/L	0.0001	<0.0001	111%
Chromium, Cr	LB064801	mg/L	0.001	<0.0010	105%
Cobalt, Co	LB064801	mg/L	0.001	<0.001	107%
Copper, Cu	LB064801	mg/L	0.001	<0.001	99%
Lead, Pb	LB064801	mg/L	0.001	<0.001	104%
Molybdenum, Mo	LB064801	mg/L	0.001	<0.001	96%
Nickel, Ni	LB064801	mg/L	0.001	<0.001	107%
Selenium, Se	LB064801	mg/L	0.003	<0.003	104%

Metals in Water (Total) by ICPOES-USN Method: ME-(AU)-[ENV]AN320/AN322

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Total Arsenic, As	LB064802	mg/L	0.003	<0.003	93%
Total Beryllium, Be	LB064802	mg/L	0.0001	<0.0001	107%
Total Cadmium, Cd	LB064802	mg/L	0.0001	<0.0001	109%
Total Chromium, Cr	LB064802	mg/L	0.001	<0.001	106%
Total Cobalt, Co	LB064802	mg/L	0.001	<0.001	106%
Total Copper, Cu	LB064802	mg/L	0.001	<0.001	103%
Total Lead, Pb	LB064802	mg/L	0.001	<0.001	105%
Total Molybdenum, Mo	LB064802	mg/L	0.001	<0.001	96%
Total Nickel, Ni	LB064802	mg/L	0.001	<0.001	108%
Total Selenium, Se	LB064802	mg/L	0.003	<0.003	106%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser   Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB064628	mg/L	0.005	<0.005	0 - 46%	102 - 103%

Nitrite in Water   Method: ME-(AU)-[ENV]AN277

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrite Nitrogen, NO2 as N	LB064813	mg/L	0.005	<0.005	0 - 2%	106 - 110%

pH in water   Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB064689	pH Units	0.1	5.2 - 5.6	0 - 1%	100%

TKN Kjeldahl Digestion by Discrete Analyser   Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB064766	mg/L	0.05	<0.05	9%	98 - 104%

Total Dissolved Solids (TDS) in water   Method: ME-(AU)-[ENV]AN113

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Dissolved Solids Dried at 175-185°C	LB064828	mg/L	10	<10	3 - 5%	103 - 115%	104 - 110%

Total Phosphorus by Kjeldahl Digestion DA in Water   Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB064766	mg/L	0.02	<0.02	0%	95 - 98%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Trace Metals (Dissolved) in Water by ICPMS in mg/L Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Uranium, U	LB064753	mg/L	0.001	<0.001	NA

Trace Metals (Total) in Water by ICPMS in mg/L Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Total Uranium	LB064757	mg/L	0.001	<0.001	NA

METHOD	METHODOLOGY SUMMARY
AN022/AN320	Total (acid soluble) Metals by ICP-OES: Samples are digested in nitric or nitric and hydrochloric acids prior to analysis for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN113	Total Dissolved Solids: A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN113	The Total Dissolved Solids residue may also be ignited at 550 C and volatile TDS (Organic TDS) and non-volatile TDS (Inorganic) can be determined.
AN121	This method is used to calculation the balance of major Anions and Cations in water samples and converts major ion concentration to milliequivalents and then summed. Anions sum and Cation sum is calculated as a difference and expressed as a percentage.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN140	Acidity by Titration: The water sample is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN248	Nitrate / Nitrite by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN277/WC250.312	Nitrite ions, when reacted with a reagent containing sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride produce a highly coloured azo dye that is measured photometrically at 540nm.

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293(Sydney)	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN280	A filtered water sample containing ammonia (NH3) or ammonium cations (NH4+) is reacted with alkaline phenol and hypochlorite in a buffered solution to form the blue indophenol colour . The absorbance is measured at 630nm and compared with calibration standards to obtain the concentration of ammonia in the sample.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Aquakem 250 Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH , and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.
AN311(Perth) /AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions taken from unfiltered sample are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
AN320/AN322	ICP-OES (Ultrasonic Nebuliser): After preservation with 10% nitric acid, a wide range of metals and some non-metals in solution can be measured by ICP- Ultrasonic nebulisation. Solutions are aspirated using an ultrasonic nebuliser into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320/AN322	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B
AN322	ICP-OES (Ultrasonic Nebuliser): After preservation with 10% nitric acid, a wide range of metals and some non-metals in solution can be measured by ICP- Ultrasonic nebulisation. Solutions are aspirated using an ultrasonic nebuliser into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN322	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:
a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

Appendix E

Groundwater Assessment, AGE 2019

Australasian Groundwater
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AMD:kc
G1789C Kidston K2-Hydro
10 January 2019

Arran McGhie
Genex Power Limited

via email

Dear Arran,

RE: Kidston K2-Hydro – Groundwater Modelling

1 Introduction

Genex Power is assessing the potential groundwater impacts posed by the proposed hydropower scheme that uses the residual voids of the former Kidston Gold Mine. The optimised Kidston K2-Hydro operation will use the Wises pit as an upper storage and the Eldridge Pit as a receiving storage, and these pits will be connected by infrastructure that includes the hydropower plant.

The operation of the hydropower scheme will involve the variation of water levels within the existing pits (including increasing the storage volume and surface area of Wises Pit), and the water level changes will induce changes with how the pits control the regional groundwater levels. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were engaged by Genex Power to undertake an assessment of the potential changes to the groundwater regime resulting from the optimised K2-Hydro operation.

2 Goals and scope of work

Goal of this project was to assess the operational design of the K2-Hydro Project in terms of its potential to impact the surrounding groundwater environment.

3 Model development and calibration

AGE used a numerical model to assess the impact of the proposed K2-Hydro modification. A model was originally developed by AGE in 2001 to examine final void hydrology and this assessment has used this model as a basis.

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3.1 Update of the 2001 AGE model

The following parts of the 2001 model were changed:

- model mesh – the refinement of the model mesh was changed to reflect the maximum increase ratio for neighbouring cells to be 1.5. The horizontal extent of the new mesh is slightly larger;
- model layers – increased from the previous three to 6 layers to better accommodate the depth of pits and simulate infrastructure;
- modelling code and solver – while the old model used then current version of MODFLOW (MODFLOW 88), the modelling code have been updated to MODFOW-SURFACT that is more suitable for conditions of steep hydraulic gradients with potential of unsaturated flow;
- extending the Wises Pit void to cover the updated area of the upper reservoir (in model layers 1 and 2); and
- implementing a horizontal flow barrier to account for the HDPE liner minimizing lateral seepage of water from the upper sections of the reservoir.

3.2 Current numerical model setup

The current numerical model setup is summarised below.

3.2.1 Model grid

The model covers area of 77.8 km^2 (9.0 km × 8.6 km) and is rotated by -22.35°. The model grid consists of 164 rows, 144 columns and 6 layers (141,696 active cells). The cell size varies from 300 m × 300 m in the areas around the edge of the model to 20 m × 20 m in the area covering the voids.

3.2.2 Model layers

The geotechnical investigations completed by Entura (2015) included seven fully cored diamond drill holes (KDDH series) around Wises Pit. The geotechnical report contains core photographs and logs which describe the degree of weathering, and include measurement of the rock quality designation (RQD) which indicates how fractured or jointed the rock mass is.

The information from the KDDH series holes indicates that the weathered/fractured zone, which is expected to enhance the movement of groundwater, is in the order of 10 m thick around Wises Pit. This is greater than the previously modelled thickness of 2 m to 3 m in the previous version of the model that utilised remote sensing data to estimate the thickness of the weathered zone. The thicknesses of Layer 1 and Layer 2 were therefore increased to a minimum of 5 m each.

The geological units were represented by six model layers:

- Layer 1 – weathered bedrock/topsoil or alluvium and spoil/tailings deposits where present;
- Layer 2 – weathered bedrock or alluvium where present;
- Layer 3 – fresh bedrock, base of layer at approximately 520 m AHD;
- Layer 4 – fresh bedrock, base of layer at approximately 498 m AHD (floor of Wises Pit);
- Layer 5 – fresh bedrock, base of layer at approximately 240 m AHD (floor of Eldridge Pit); and
- Layer 6 – fresh bedrock, base of the model at 30 m AHD.

3.2.3 Hydraulic properties

Based on previous studies and in-situ testing described in AGE (2001), the hydraulic conductivity of bedrock material is characterized as 'tight' and varies from 5×10^{-9} m to 9×10^{-7} m/day. The investigation undertaken by Entura (2015) describes in-situ tests on seven bores (KDDH01 to KDDH07) and shows hydraulic conductivities higher than described previously, varying from less than 8.6×10^{-4} m/day to more than 8.6×10^{-1} m/day with average of 4×10^{-2} m/day. The records indicate that packer tests were undertaken on both 'fresh' and 'weathered' intervals and their results are skewed upwards by testing of the weathered zone. The hydraulic conductivity values were used to constrain the calibration process.

The weathered zone and fresh bedrock in the model were divided into four zones to represent the regionally extensive geological units. These zones represent Oak River granodiorite, Kennedy Province rhyolite, Einasleigh metamorphics and polymict breccias associated with the Kidston ore deposit mineralization. Zones were also created within the model to represent mine waste rock dumps, tailings deposits and alluvium aligned along surface streams.

The updated zonation of hydraulic properties is presented on Figure 1. The increased extent of Wises pit can be seen by the dashed line in the left panel of Figure 1, which represents the liner applied to the upper layers (Layer 1 to 2) in the model, and the purple coloured zone representing the void.

3.2.4 Recharge

Average annual rainfall ranges between 620 mm to 698 mm (AGE 2001) with much higher evaporation rates up to 1868 mm/year (CSIRO 2013) indicating a rainfall deficit. The actual effective recharge is estimated to be quite low – less than 5 mm/year (CSIRO 2013). Recharge within the model was varied using the geological zones described above to represent the potential variability due to geology.

LEGEND

----- horizontal flow barrier

🟩 Topsoil, weathered regolith
🟩 Alluvium
🟧 Northern spoil
🟦 Tailings dam
🟪 Void – Wises Pit
🟦 Void – Eldridge Pit

🟥 Oak River granodiorite
🟧 Kennedy Province rhyolite
🟧 Einsleigh metamorphics
🟨 Polymict breccia
🟪 Void – Wises Pit
🟦 Void – Eldridge Pit

Kidston K2-Hydro (G1789C)

Zonation of hydraulic properties in model layers 1-2 and 3-6

DATE
10/01/2019

FIGURE No:
1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/1_zones_hydraulic_properties.qgs

3.3 Model calibration

The model was calibrated against available groundwater level measurements from monitoring bores. Data from 61 observation bores were available, of which 38 sites were actually used during the calibration process (Figure 2). Many of the observed water levels are historical observations collected during periods of active mining and are not expected to accurately reflect current water levels across the site. These bores were therefore removed from the calibration dataset. The majority of recent water level measurements are from piezometers around the tailings dam to the south of the pits. Whilst this provides a high degree of control in this area of the site there are other areas of the model, such as around Eldridge pit, where current water levels are unknown.

Table 1 presents the simulated and the measured groundwater levels for the calibrated model and the difference between these levels (the residuals).

Table 2 summarises the hydraulic conductivity values adopted for each geological zone. The calibrated hydraulic conductivities for the bedrock units in this simulation were at the higher end of the measured ranges. This version of the model is therefore expected to allow groundwater to move more freely through the bedrock than if lower values were adopted.

The calibrated recharge across the undisturbed areas of the model was relatively low at <3 mm/yr, whilst higher rates were incorporated over the alluvium and the areas disturbed by mining (spoil and tailings). A review of water quality measurements indicates the groundwater generally has a low salinity that would suggest moderate recharge rates; the fact the numerical calibrated well to a low recharge indicates some uncertainty in this parameter within the model.

A post-calibration scatter diagram is shown in Figure 3, with the main statistical indicators of the calibration in Table 3.

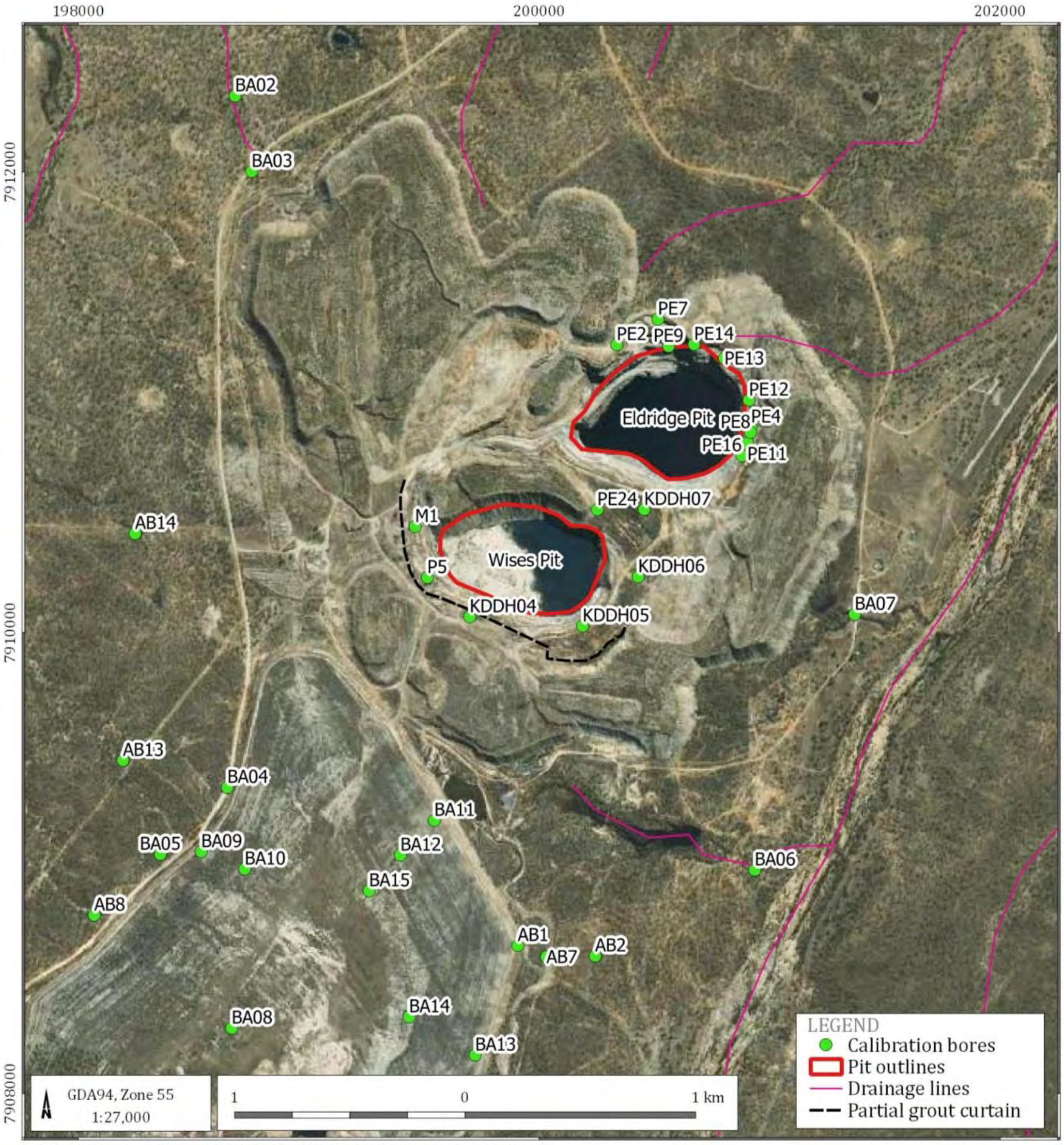

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Figure 2 Calibration bore locations

Table 1 Steady state calibration - residuals

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
AB1	199908	7908642	544.6	540.3	4.3
AB2	198194	7909446	533.7	537.7	-3.9
AB7	198247	7910431	525.4	526.9	-1.5
AB8	200244	7908597	516.1	527.0	-11.0
AB13	200032	7908593	531.4	533.0	-1.6
AB14	198070	7908774	541.4	544.5	-3.2

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
BA02	198681	7912331	521.6	518.9	2.6
BA03	198753	7912003	526.0	517.7	8.2
BA04	198647	7909329	547.3	541.4	6.0
BA05	198357	7909039	545.0	544.0	1.1
BA06	200936	7908971	508.1	512.0	-4.0
BA07	201370	7910080	510.3	508.0	2.2
BA08	198666	7908284	545.8	548.4	-2.6
BA09	198534	7909050	544.2	544.9	-0.6
BA10	198723	7908974	549.4	544.8	4.6
BA11	199545	7909186	540.9	538.8	2.1
BA12	199398	7909035	544.0	540.1	3.9
BA13	199723	7908167	540.0	542.7	-2.7
BA14	199436	7908333	542.0	544.0	-2.0
BA15	199262	7908880	545.3	542.0	3.2
BA16	197379	7910486	524.4	526.5	-2.1
KDDH04	199699	7910069	527.9	513.6	14.3
KDDH05	200189	7910029	515.0	509.8	5.2
KDDH06	200430	7910243	527.3	506.9	20.4
KDDH07	200456	7910535	519.0	495.4	23.5
M1	199462	7910461	516.8	514.0	2.8
P5	199515	7910240	508.5	514.9	-6.4
PE2	200904	7910824	480.9	486.6	-5.7
PE4	200911	7911010	490.4	485.1	5.4
PE7	200804	7911192	503.6	486.9	16.6
PE8	200673	7911252	500.0	483.2	16.8
PE9	200880	7910769	496.0	487.3	8.6
PE11	200337	7911251	509.9	501.3	8.6
PE12	200253	7910535	500.2	498.6	1.6
PE13	200920	7910893	508.4	488.1	20.2
PE14	200516	7911361	531.4	509.2	22.2
PE16	200918	7910870	509.7	487.5	22.2
PE24	200562	7911244	481.2	482.0	-0.8

Table 2 Calibrated hydraulic properties

Matrix description		Hydraulic conductivity (m/day)	
		Horizontal (Kh)	Vertical (Kv)
Topsoil		0.1	0.02
Alluvium		0.5	0.025
Spoil		4.0	0.4
Tailings		0.7	0.0007
Weathered profile	Oak River granodiorite	0.08	0.004
	Kennedy Province rhyolite	0.005	0.005
	Einasleigh metamorphics	0.007	0.007
	Polymict breccia - ore mineralization	0.005	0.00025
Fresh bedrock	Oak River granodiorite	0.007	0.002
	Kennedy Province rhyolite	0.008	0.008
	Einasleigh metamorphics	0.002	0.002
	Polymict breccia - ore mineralization	0.0001	0.0001

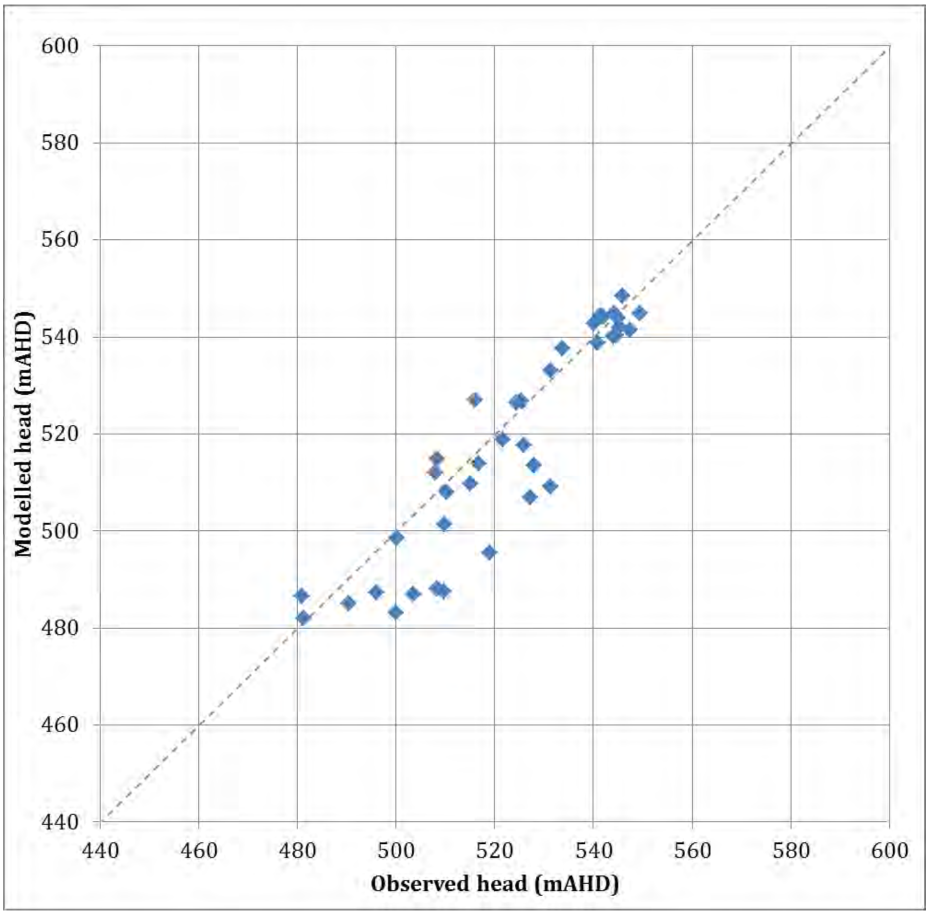


Figure 3 Steady state calibration – scatter diagram of modelled against observed heads

Table 3 Main statistical indicators of calibration process

Statistical indicator		Value	Units
SSQ	Sum of squared residuals	3793	(m^2)
RMS	Root mean square	9.99	(m)
SRMS	Scaled RMS	14.6	(%)

The SRMS is one of the main indicators of calibration fit and at 14.6% it is considered to be slightly poor. This indicates that some processes in the natural environment are not represented in the model. The model was calibrated to assumed steady state water levels, which are estimates of long term average water levels. The available monitoring data suggests the water levels within the mine pits have not reached equilibrium and are therefore not likely to represent the long term average level. The water level measurements within the monitoring bores are also sporadic and may not represent the full fluctuations that occur across the wet season and dry season climatic cycles. The model also assumes the hydraulic properties of the geologic units are uniform across large areas, which is of course not true within the natural environment. These aspects likely combine to result in the slightly poor calibration.

3.4 Model predictions

In order to assess the impact of the Project, each pit was assigned a water level that explores the maximum possible water level gradient between Wises and Eldridge pits. The setup of the model in terms of defined water levels is shown in Table 4.

Table 4 Modelled scenarios – pit water levels

Scenario	Simulated water level in reservoirs (mRL)	
	Wises Pit (upper, shallow)	Eldridge Pit (lower, deep)
Baseline	492.00	480.75
K2-Hydro	551.00 *	328.40

Note: ** This is a conservative level as the Maximum Operating Level for Wises Pit is 546 mRL. The MOL is achieved when the Eldridge Pit water level is at elevation 328.40 mRL.*

4 Modelling results

Two steady state models were run with the setups described in Table 4. The potential impacts of the K2-Hydro modification were determined through comparisons between these two model predictions. The key model outputs used to determine the impact were predicted groundwater table (groundwater mounding and drawdown analysis) and changes to water budgets for predicted pit inflow/outflow and flows to the Copperfield River. A simple particle tracking exercise was also undertaken to better understand the extent of the impacts in the context of the limitations of the steady state model with respect to the real-life duration of the Project (50 years).

4.1 Groundwater levels

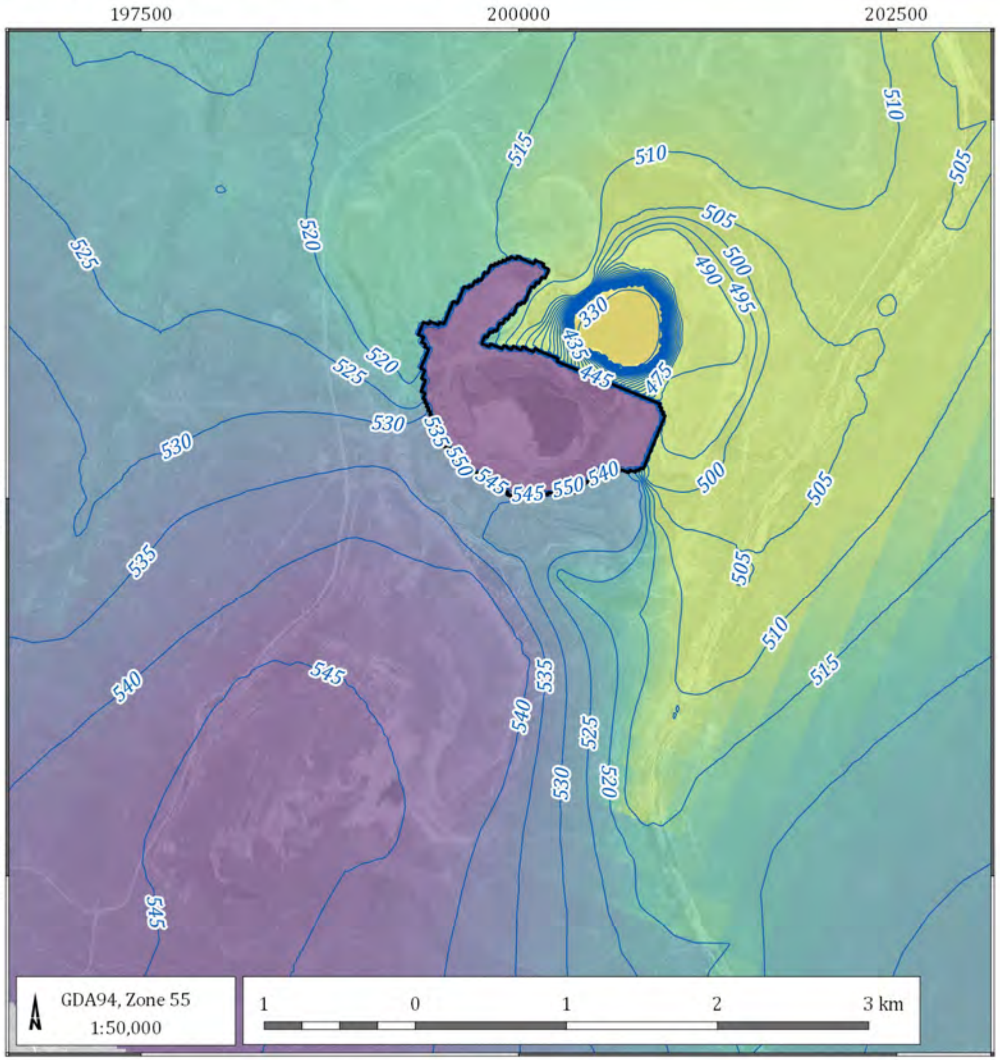
Figure 4 below shows predicted heads (left) and predicted difference to the baseline simulation (right) in model Layer 1 (representing the phreatic surface) for the K2-Hydro setup in Table 4. The predicted difference shows both drawdown (positive contours) and mounding (negative contours). Generally, the water seeps through the floor of the upper reservoir and travels down-gradient where it is either captured by the Eldridge Pit or remains in the groundwater system and results in a rise in the water table level. Because the water level in the Wises reservoir (551 m RL) is relatively high and above the existing water table, the model predicts an increased seepage and water level rise in the immediate vicinity of the pit towards the west, southwest and south. The elevated water table around Wises pit from this seepage 'dams' the regional flow towards the north and the backed up water results in additional mounding in the areas south and southwest from the Wises reservoir.

4.2 Particle tracking

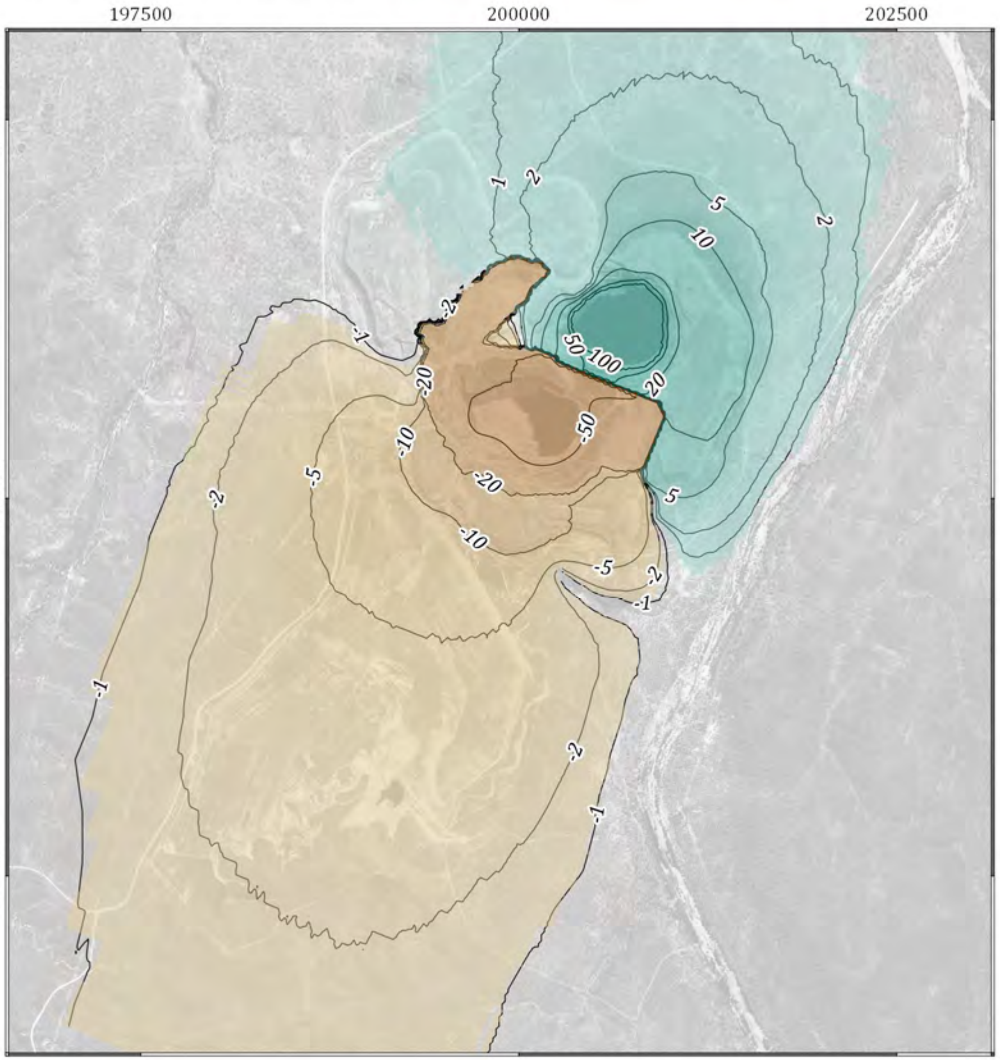
Particle tracking was used to identify the likely travel distances of water particles that start their journey in the Wises reservoir at the start of the Project. The distance of travel of particles indicates the spatial extent of the likely impacts from the Project over its operational phase. The pathlines for 100 years timeframe were generated, as these were comfortably past the expected lifetime of the Project (50 years).

Particles were started inside the lined pond (see Figure 5). Particles released on the north eastern side of Wises Pit generally migrate to the Eldridge pit. However, the particles released in other parts of the reservoir migrate in a west, south or south-west directions remain "active" in the groundwater system. During the 100 year timeframe run, only 4 (out of 54) particles ended up in the Eldridge Pit, all the other particles remained active after moving in the downwards direction through the bedrock units. Regardless of the length of the particle tracking timeframe, the travel of particles in south and southwest direction is limited. This is likely to be due to the northerly gradient being maintained from the tailings dam area towards the north. No particles made it to Copperfield River in the 100 year period.

K2-Hydro - predicted groundwater heads



K2-Hydro - predicted drawdowns



LEGEND

— contour - heads

— contour - drawdown

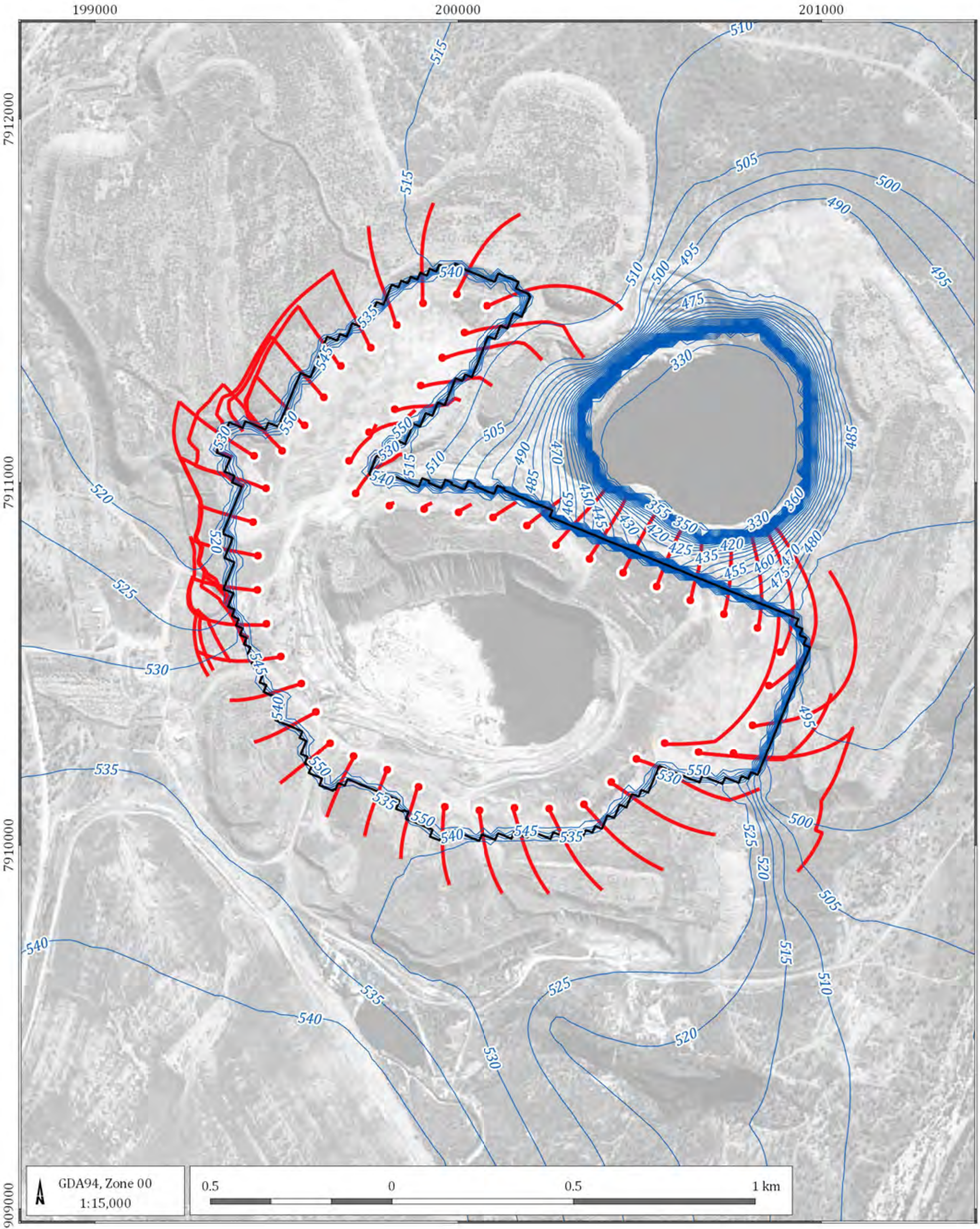
Kidston K2-Hydro (G1789C)

Heads and drawdowns

DATE
10/01/2019

FIGURE No:
4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/2_heads_drawdowns.qgs



LEGEND

- ▬ horizontal flow barrier
- ─ contour - groundwater head
- ● initial particle position
- ▬ particle trace

Kidston K2-Hydro (G1789C)

Particle tracking - 100 years

DATE
10/01/2019

FIGURE No:
5

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/3_particles.qgs

4.3 Predicted water balance for the pits

Under current conditions (pre-development baseline), both pits act as sinks because their water level sits slightly below the observed regional water table. Shallower Wises Pit receives approximately 19 m^3/day, while deeper Eldridge pit receives approximately 270 m^3/day (see Table 5). Under operating conditions (Scenario A), the water level in Wises Pit will be above regional groundwater table and becomes water source as the pit will be losing 350 m^3/day, while Eldridge Pit (lower reservoir) will remain sink with potential inflows of 770 m^3/day. In net terms, the operational conditions increase the inflow to pits from 290 m^3/day (pre-development baseline) up to 420 m^3/day (K2-Hydro project in place with maximum groundwater gradient).

Table 5 Water balance for Wises and Eldridge pits

Scenario	Predicted groundwater inflows (m^3/day)		
	Wises (upper, shallow)	Eldridge (lower, deep)	Net interception of groundwater
Baseline	19	271	290
K2-Hydro	-350	770	420

What has been demonstrated through pathline analysis and groundwater level change is that the increased inflow into Eldridge pit during the operational phase will be sourced from both Wises pit seepage and inflow from surrounding groundwater in all directions around the pit.

4.4 Predicted interaction with Copperfield River

The boundary condition representing Copperfield River was set up as a potential water source with capability to both remove water from the environment in the form of baseflow, as well as contribute to the groundwater system via river bed recharge.

In order to estimate the impact of the Project on the Copperfield River, the model domain was divided into water balance zones as presented in Figure 6. The water balances were calculated separately for the “northern” (red) and “southern” (green) sections of the river, as it is expected the impact will be different in these sections: the northern part will be more influenced by lowering the groundwater levels in the vicinity of Eldridge Pit, the southern part will be potentially impacted by additional baseflow from elevated groundwater levels due to Wises Pit and the tailings dam south of Wises Pit. The water balances (net flow rates) are presented in Table 6.

LEGEND

🟦 bedrock - west
🟨 bedrock - east
🟥 river - north
🟩 river - south

— horizontal flow barrier

Kidston K2-Hydro (G1789C)

Water balance zones - Copperfield River

DATE
10/01/2019

FIGURE No:
6

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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Table 6 Zone water balances for Copperfield River

Scenario		From west (m^3/day)	From east (m^3/day)	Net inflows (m^3/day)
Baseline	Northern section	157	337	690
	Southern section	64	132	
K2-Hydro	Northern section	88	257	543
	Southern section	65	133	

The analysis of the zone water balance is showing that the Copperfield River is both losing water in the form of river bed recharge and gaining water in the form of baseflow, with the baseflow dominant of the two. The river generally acts as a conduit removing water from the groundwater system. The extreme operational conditions (low water level in Eldridge pit, high water level in Wises pit) impact on the groundwater system by the following way:

- Overall, the baseflow to the river will decrease by 150 m^3/day from 690 m^3/day (current baseline condition) to 540 m^3/day.
- The northern section of river within the model domain will see a decrease of baseflow due to the increased gradient towards the nearby Eldridge Pit. The decrease of baseflow impacts flows from both west and east. The decrease of baseflow from the western side of the river (Eldridge Pit) was estimated to be ~70 m^3/day (44% of the baseflow predicted to occur in the model domain).
- The southern section of the river is predicted to see a very slight increase of flow from the west (caused by increased gradient towards the Copperfield River due to the mounding in tailings dam area). The flows from the east remain more or less unchanged (increase of 1.1 m^3/day). The increase of baseflow from the western side (tailings dam) presents an additional 1 m^3/day, which is ~1.6% increase over the baseline predicted baseflow.

The reduced inflow (baseflow) for the western side of the northern zone is expected during the Project operation because of its proximity to Eldridge pit that draws the water table down increasing the groundwater inflow to the pit. There is also a reduced baseflow from the east of Copperfield River due to the cone of depression extending under the river immediately adjacent to the Eldridge Pit.

There is a relatively minor increase in the flow to the southern zone of the Copperfield River through the model domain. This slight increase of just under 2 m^3/day from the west, is due to slightly higher groundwater levels due to the damming effect of the Wises Pit on the regional groundwater flow.

4.5 Predicted impact on groundwater potentially associated with Groundwater Dependent Ecosystems (GDEs)

The National Atlas of Groundwater Dependent Ecosystems (BoM, 2018[1]) maps locations of potential terrestrial groundwater dependent ecosystems that rely on the subsurface presence of groundwater to meet all or some of their water requirements based on national scale mapping. The GDE atlas also includes potential areas of GDEs which use groundwater after it has been discharged to surface (aquatic GDEs).

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[1] Bureau of Meteorology, 2018. Groundwater Dependent Ecosystem Atlas, Website: http://www.bom.gov.au/water/groundwater/gde/ downloaded November 2018.

Permanent springs are recorded in the Queensland Springs database (DES, 2018[2]). The database also includes details of non-permanent springs, although the information on these can be limited.

Figure 7 shows the location of the potential GDEs and identified springs around the Kidston site, along with the predicted changes in groundwater level resulting from the extreme operational limits of the K2 Hydro scheme. It is important to remember that water levels are predicted to rise around Wises Pit and fall around Eldridge Pit.

The figure indicates that terrestrial GDEs may be present over large areas of land close to the K2-Hydro Project. Areas of highest potential are located along the drainage lines. It is possible that high potential GDEs along the Copperfield River could see a reduction in groundwater as a result of the Project. The majority of the area predicted to draw down by more than 1 m is unclassified over the historically disturbed mining areas, or at low potential for terrestrial GDEs.

Potential aquatic GDEs are located along many of the nearby drainage lines, with the locations correlating strongly with the high potential terrestrial GDE mapping. The majority of aquatic GDEs are classified as moderate or low potential, with a small area of high potential along the Copperfield River to the northeast of the K2-Hydro Project. It is possible that GDEs along the Copperfield River could see a reduction in groundwater inputs as a result of the K2-Hydro Project.

Although there are potential changes in groundwater levels predicted in the vicinity of several potential GDEs additional work will be required to determine if the changes could result in a negative impact to the vegetation communities.

There is one permanent spring (SPR482 – Middle Spring), located approximately 4.8 km west-northwest of the Project. This is close to the edge of the model domain and is predicted to be impacted by less than 0.2 m from a very conservative steady state assessment.

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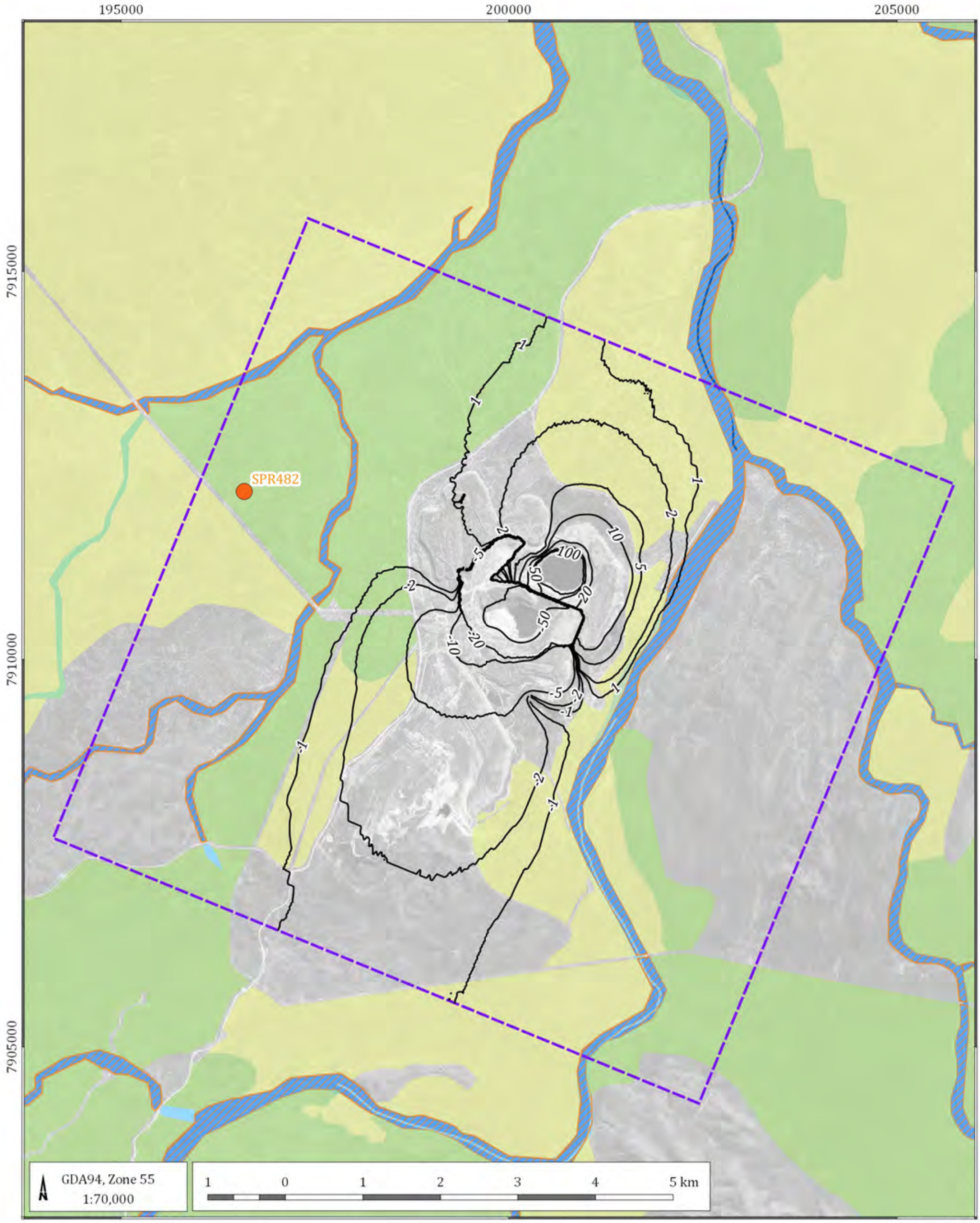
[2] Department of Environment and Science, Queensland Government, 2018. Springs database, version 11/09/2018.



LEGEND

● Springs

— Drawdown contour

▭ Model extent

Terrestrial GDEs

▨ High potential GDE

🟩 Moderate potential GDE

🟨 Low potential GDE

Aquatic GDEs

🟦 High potential GDE

🟦 Moderate potential GDE

🟦 Low potential GDE

Kidston K2-Hydro (G1789C)

Predicted drawdown and nearby GDEs

DATE
10/01/2019

FIGURE No:
7

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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5 Conclusion

5.1 Impacts of the project

Impacts of the projects were described in terms of lowering or raising water levels in the groundwater system and changing the baseflow and recharge rates with respect to the surface drainage, namely Copperfield River.

If the increased groundwater gradient caused by the difference of water levels between Wises and Eldridge pits remained in place indefinitely, the groundwater regime would be altered in the following way: groundwater table below the tailings dam would rise by 2 m to 5 m due to Wises pit damming up and reducing regional groundwater movement to the north of the spoil, while groundwater levels surrounding the Eldridge pit would be lowered. The mounding in the southern tailings area would marginally increase the baseflow to the Copperfield River. The cone of depression developed around Eldridge pit would extend up to 3000 m in the north-eastern direction (from the Eldridge Pit) and approximately 1300 m towards the Copperfield River and decrease the baseflow contribution adjacent to the Eldridge Pit.

These predictions are however conservative as they are based on the steady state model. The particle tracking exercise demonstrated that in the short timeframe that spans the lifetime of the project, the drawdown and mounding impacts will not have time to develop to the same extent as the steady state model predictions indicate.

During the Project operation, the increased inflow of groundwater to Eldridge pit will reduce the baseflow occurring to Copperfield River. This water will be collected by the pit and become part of the operation. When an opportunity of increased flow in Copperfield River occurs (due to a rainfall event), the poorer quality water could be released back to the river (if required) and the dilution would result in better overall water quality in the river than it being baseflow in low flow conditions.

The flow to the west, south and southwest should be considered temporary during the Project life. This seepage from Wises pit is not predicted to travel far during the life of the Project as indicated by the conservative 100 year pathlines. At the end of the project, when the head in Wises is no longer maintained, the capture zone of Eldridge pit will increase and it is entirely likely that the drawdown cone of depression for Eldridge will be recharged by the water lost from Wises during the project operation. Water levels in both pits can be expected to return to their pre-project elevations.

5.2 Limitations of the model

The model in its current form (steady state) with its simplifying assumptions is satisfactory for understanding the conceptual issues surrounding the Project, however it is not capable of quantifying the impacts on the timescale of the project. In this sense, the model is very conservative when considering the extent of impacts.

6 References

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