



Ammaroo Ammonium Phosphate Fertiliser Project

Referral for Significant Variation Appendices A - I

Verdant Minerals Pty Ltd

9 November 2022



Appendix A

**Summary of Proposed Project Impact on
Approved Project EIS Conditions**

Table A 1 Proposed Project comparison to Approved Project EIS Conditions

Project Component	No.	Recommendations of the Approved Project	Existing Recommendations Adequate	Comments
Assessment of environmental factors	1	The Ammaroo Phosphate Project is implemented in accordance with all environmental commitments and safeguards.	Yes	Verdant will implement the Proposed Project in accordance with environmental commitments and safeguards.
	2	That the Proponent provides written notice to the Northern Territory Environment Protection Authority and the Responsible Minister if it alters the Ammaroo Phosphate Project and/or commitments, safeguards, or mitigation measures in the Environmental Impact Statement in such a manner that the environmental significance of the action may have changed, in accordance with clause 14A of the Environmental Assessment Administrative Procedures	Yes	Project scope has changed, which has triggered the preparation of the referral of significant variation.
WMP (Aquifer)	3	That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Water Abstraction Management Plan to the relevant regulator prior to mining.	Yes	A revised Groundwater modelling study has been completed for inclusion into the referral document. WAMP will reflect revised water requirements.
WMP (Water Usage)	4	That approvals and decisions for the Proposal have conditions that require the Proponent to:	Yes	No change to the basis of the recommendation. Verdant would continue to adhere to all of these conditions.
	4.1	Allocate clear responsibilities and accountabilities for water use and management		
	4.2	Provide regular updates of the projected water balance for the Proposal in the Water Management Plan, including detailed estimates for the various phases of the Proposal and specifying the source and quantity of the water to be used		
	4.3	Demonstrate how water saving considerations are integrated in Proposal planning including final design and technologies		
	4.4	Report on continual improvement initiatives in water use efficiency including the provision of relevant water use targets Assessment Report 87 NORTHERN TERRITORY ENVIRONMENT PROTECTION AUTHORITY 19		
	4.5	Provide details on how water will be effectively managed during proposed operations, including minimising water consumption, maximising water reuse and minimising wastewater		
	4.6	Abstract water from bores only when equipped with operating flow meters		
	4.7	Record the volume of water abstracted from the bore field and the corridor construction bores		
	4.8	Report water use performance in relation to targets, and any change to targets in an annual Water Management Report to stakeholders		

Project Component	No.	Recommendations of the Approved Project	Existing Recommendations Adequate	Comments
WMP (Seepage)	5	That approvals and decisions for the Proposal have conditions that require the Proponent to:	Yes	No change, the Water Management Plan would include the gypsum stacking area (GSA) and other infrastructure. Annual review and reporting would continue.
	5.1	Update the seepage monitoring program in the Water Management Plan to include recommendations of the independent peer review		
	5.2	Annually review and, if required, update the seepage model. Findings of the review and updates to the seepage model should be reported in the annual Water Management Report.		
AMDMP	6	That approvals and decisions for the Proposal have conditions that require the Proponent to provide an updated Acid and Metalliferous Drainage Management Plan to the relevant regulator prior to mining that: Assessment Report 87 NORTHERN TERRITORY ENVIRONMENT PROTECTION AUTHORITY 24	Yes	The Proposed Project has eliminated the surface tailings facility and will store tailings within mined out pits. The volume of tailings has been reduced through application of dry ore sorting of ROM feed prior to wet beneficiation. Further leachate testing results have been included with the referral appendices (Appendix H). This recommendation addressed the Approved Project scope which did not include a gypsum by-product. The impact of the inclusion of gypsum and the design of gypsum stacking area (GSA) will be managed applying the same recommendations and conditions.
	6.1	Incorporates the recommendations of the independent peer review and all commitments made by the Proponent in the Environmental Impact Statement including further testing in the pre-production phase (geochemical testing of tailings and ore, identification of suitable capping/encapsulation material and additional NAG and NAPP testing)		
	6.2	Includes aggressive leach testing of tailings prior to mining with the results to be reported to the relevant regulator for assessment and, if required, identification of appropriate mitigation measures.		
	6.3	Incorporates a program to analyse in-situ extracts of tailings seepage and decant water during the first 12 months of operation with the results to be reported to the relevant regulator for assessment and, if the seepage composition exceeds the agreed threshold levels, then mitigation options such as lining the tailings storage or additional tailings treatment must be implemented immediately		
	6.4	Includes a program for regular geochemical testing of all materials scheduled for mining or in constructed landforms (including ore stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested		
	6.5	Includes a contingency plan outlining trigger levels for actions, specific responses and mitigation measures, and consequences for operational, rehabilitation and closure activities. The Acid and Metalliferous Drainage Management Plan should be developed and implemented to the satisfaction of the relevant regulator.		
	7	That the Acid and Metalliferous Drainage Management Plan, referenced at Recommendation 6, includes a program for regular radiological testing of all materials scheduled for mining or in constructed landforms (including ore	Yes	No change except will include of the gypsum stacking area (GSA)

Project Component	No.	Recommendations of the Approved Project	Existing Recommendations Adequate	Comments
		stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested.		
WMP (Surface Water)	8	That approvals and decisions for the Proposal have conditions that require the Proponent to develop a Water Management Plan to the satisfaction of the relevant regulator prior to mining. The plan should include:	Yes	The WMP would be updated to include the gypsum by-product and the GSA and other infrastructure with potential to impact the WMP. Groundwater quality monitoring program would continue.
	8.1	An assessment of chemicals added during water treatment and the beneficiation process, including an assessment of their behaviour and breakdown products in tailings and tailings decant/seepage and potential to contaminate the environment. In particular: - clearly identifying the type of polyacrylamide and polymer flocculants - polyacrylamides with more than 0.05% of the neuro-toxin acrylamide monomer are not to be used		
	8.2	Recommendations of the independent peer review to monitor seepage during the early stages of mine development		
	8.3	Robust pre-mining groundwater quality baselines to be used as trigger levels for mitigation measures, or should no groundwater be present, livestock drinking water guidelines to be used as trigger thresholds		
	8.4	In line with the program to monitor potential contamination sources (Recommendation 6) potential contaminant concentrations in waste rock and tailings leachate should be identified and used as trigger thresholds for management actions to mitigate the source of contamination		
	8.5	Contingency measures to mitigate the source of contamination, if trigger values are exceeded Assessment Report 87 NORTHERN TERRITORY ENVIRONMENT PROTECTION AUTHORITY 28		
	8.6	A robust groundwater quality monitoring program that can quantify the extent and quality of any potential seepage from the proposed mine site		
	8.7	A requirement for an independent external audit of the groundwater quality monitoring program by a suitably qualified and experienced professional after four and ten years of tailings deposition. The auditor is to report to the relevant regulator. All water quality monitoring data, trigger values, audit reports and an assessment of any impacts should be made publicly available in an annual Water Management Report on the websites of (as applicable) the Proponent, the Operator, and relevant regulatory authorities.		
Vegetation	9	That the Proponent rehabilitate and revegetate all sections of the infrastructure corridor not required during the operational phase shortly after construction has been completed. Revegetation is to use local native plant species.	Yes	No change to the basis and compliance to the recommendation for the Proposed scope.

Project Component	No.	Recommendations of the Approved Project	Existing Recommendations Adequate	Comments
Whole of environmental considerations	10	That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Mine Closure Plan to the relevant regulator prior to mining. The Mine Closure Plan must:	Yes	The mine plan has not changed for the Proposed Project, other than elimination of the surface tailing facility and the addition of the GSA.
	10.1	Be of a standard equal to or better than the Western Australian guidelines for preparing mine closure plans (DMP, 2015)		The Mine Closure Plan will be amended prior to mining and will incorporate the long-term management of the GSA.
	10.2	Address all aspects of rehabilitation and mine closure, including postmining land use agreed with stakeholders, rehabilitation objectives, schedules for progressive rehabilitation, completion criteria and monitoring of rehabilitation success		The GSA will remain a landform beyond closure of operations of the mine and will be rehabilitated to eliminate long-term environment impact. The landform will be capped with appropriate material to facilitate re-establishment of native flora as far as possible.
	10.3	Include predicted landform designs that are consistent with current standards and best practice		
	10.4	Include plans and a schedule for post-construction rehabilitation of all areas of the infrastructure corridor that would no longer be required after construction		
	10.5	Demonstrate that all rehabilitated areas would be safe to humans and animals, geotechnically stable, non-polluting, and non-contaminating, and capable of sustaining the agreed post-mining land use		
	10.6	Include details of the research trials and investigations that would inform, guide, and support appropriate landform covers and ecosystems for all rehabilitation, including progressive rehabilitation and closure		
	10.7	Investigate the long-term settling process of tailings and waste rock to inform construction of appropriate landform covers and avoidance of significant depressions and pooling of water		
	10.8	Provide details of a program for regular monitoring and reporting on the performance of progressive rehabilitation works		
	10.9	Provide for results from monitoring the performance of progressive rehabilitation to inform decision-making to ensure long-term successful rehabilitation		
	10.1	Outline a strategy for appropriate consultation with stakeholders on rehabilitation objectives and post-mining land use		
	10.11	Provide for ongoing monitoring and maintenance of the site postmining, in accordance with an approved monitoring and maintenance program, until such time as the relevant regulator directs		
	10.12	Require reporting to the relevant regulator on progressive rehabilitation works and performance		
	10.13	Require independent external audits by suitably qualified and experienced professionals of the progressive rehabilitation, including revegetation, at least		

Project Component	No.	Recommendations of the Approved Project	Existing Recommendations Adequate	Comments
		every five years and at closure. The Mine Closure Plan is to be peer-reviewed by an appropriately qualified independent professional prior to submission to the relevant regulator.		
Whole of environmental considerations	11	That approvals and decisions for the Proposal have conditions that require future iterations of the Mine Closure Plan to include:	Yes	The Proposed Project will comply with this condition. The Mine closure plan will be updated to include the Proposed Project
	11.1	Alternative rehabilitation options that identify a range of closure scenarios and strategies for the mine pit and associated infrastructure and provide justification that the preferred closure option minimises environmental risks		
	11.2	Identification and management of knowledge gaps relating to closure specific technical information (including environmental baseline data, waste characterisation, and review of monitoring data) to inform sustainable mine closure		
	11.3	Details of pre-closure research trials, investigations and modelling aimed at addressing knowledge gaps to inform detailed rehabilitation design. These are to include, but are not limited to, vegetation, final cover materials, capping design, and surface water runoff.		
People	12	That approvals and decisions for the Proposal include conditions that require the Proponent to demonstrate appropriate engagement with native-title holders, and to establish a Community Consultation Group with Aboriginal, pastoral, and other relevant stakeholders to provide a forum to:	Yes	Engagement with Community Consultation Group ongoing and includes consultation relating to the Proposed Project. Furthermore, Verdant are committed to continuously work with the Traditional Owners and Central Land Council to finalise the Native Title Agreement and governing structure, identify opportunities for community and Local Industry Participation Plan to reflect increase in potential opportunities for local businesses.
	12.1	Inform (in an appropriate manner) local residents of key aspects of the Proposal that may impact on their values, including amenity and cultural practices		
	12.2	Consult with local residents and relevant agencies on matters relating to the proposed workforce, to maximise benefits for local employment, and to manage cumulative impacts on demand for local workers and overall employment opportunities		
	12.3	Undertake ongoing stakeholder consultations on agreed post-mining land use and rehabilitation objectives		

Appendix B

**Proposed Project comparison to NT EPA
Environmental Factors**

Table A 2 Proposed Project comparison to NT EPA Environmental Factors

Environmental factor	Approved Project potential impacts	Proposed Project - key environmental factor status	Existing recommendations adequate
Terrestrial Flora and Fauna	Clearing of 3775 ha of native vegetation.	No change in total land clearing	Yes
	The grey falcon, is likely to occur in the Proposal area.	No change from the Approved Project	Yes
	Discovery of threatened species	A desktop review in July 2022 detailed one additional fauna species (Ghost Bat, <i>Macroderma gigas</i>) not assessed in the previous Approved EIS as potentially occurring within the Project area. However, there are no known historic records of this species within the Project area. The Ghost Bat is listed as Vulnerable under the EPBC Act and Near Threatened under the TWPC Act. Ghost Bats have not been identified in arid Australia and are considered regionally extinct in central Australia (Milne and Pavey, 2011), with only small, isolated populations in Northern Australia. During the survey undertaken in 2017, there was no suitable habitat present within the Project area to support foraging, breeding, or roosting of the species. The Ghost Bat's likelihood of occurrence has been assessed in this EIS Referral. Given that there are no previous records for the Ghost Bat within the Project area coupled with the lack of suitable habitat it is considered unlikely for the Ghost Bat to occur. No change from the Approved Project.	Yes
	Fauna entrapment - there is some potential for fauna mortality from entrapment in trenches required for the gas pipeline construction.	No change from the Approved Project, no additional trenching for the gas pipeline proposed.	Yes
	Contaminated water, standing water associated with the tailing's storage facility and in-pit tailings disposal could contain contaminants that could impact native fauna species by contact or consumption.	Surface tailings facility no longer required. In-pit tailings will be managed appropriately. Gypsum stacking facility designed and constructed to meet relevant standards to minimise risks.	Yes
	Vehicle strikes - fauna may be killed or injured by strikes from vehicles used for the Proposal on roads and rail	No change from the Approved Project, there will be some increased daily traffic movements, but these are not considered a significant additional risk.	Yes
	Introduction and spread of weeds - the Proponent identified 13 weed species in the Proposal area, including the declared weed <i>Calotropis procera</i> (rubber bush), as well as the invasive pasture grass <i>Cenchrus ciliaris</i> (buffel grass) (DoE, 2015). Implementation of the Proposal could assist the distribution of these species or introduce new species. Any weed species can alter the composition of native vegetation	No change from the Approved Project, weed infestation control measures considered adequate to manage impacts from weeds and increased traffic during construction period.	Yes

Environmental factor	Approved Project potential impacts	Proposed Project - key environmental factor status	Existing recommendations adequate
	(and thereby potentially alter fauna habitat suitability) by competition and/or other mechanisms such as changing the fire regime.		
	Competition/predation from introduced fauna - the Proposal would introduce new sources of water (and potentially food) to the landscape that may increase the density of non-native fauna that compete with, or predate on, native fauna.	No change from the Approved Project	Yes
Terrestrial environmental quality	Soil contamination	Introduction of chemical processing and GSA. However, control measures to reduce risk of soil contamination from these sources are considered adequate.	Yes
	Erosion and sediment movement	No change from Approved Project, erosion control measures considered adequate.	Yes
	Rehabilitation failure	GSA to be included in closure plan. This is considered adequate to not change risk profile.	Yes
Landforms	There are no distinctive physical landforms in the area of the Proposal.	Gypsum stack altering natural landform to create a visual change for sensitive receptors. However, the Mine Closure Plan will be amended prior to mining and will incorporate the long-term management of the GSA. The GSA will remain a landform beyond closure of operations of the mine and will be rehabilitated to eliminate long-term environment impact. The landform will be capped with appropriate material to facilitate re-establishment of native flora as far as possible. This is considered adequate to not change risk profile.	Yes
Aquatic ecosystems	There are no aquatic ecosystems in the Proposal area.	No change from the Approved Project.	Yes
Air quality	Dust generation would be generated by wind over disturbed or cleared areas, mining activities (excavation, loading, grading, hauling), beneficiation, and by vehicle movement on dirt roads	No change from the Approved Project, air quality dispersion modelling completed and demonstrated no impact on receptors. Dust management controls considered adequate.	Yes
Atmospheric processes	Greenhouse gas emissions implementation of the Proposal would result in the unavoidable emission of greenhouse gases from land clearing, construction, vehicle emissions, and energy generation.	Increase due to ammonia manufacturing. Greenhouse Gas Abatement Plan to be submitted in accordance with the Large Emitters Policy.	No
Marine environmental quality	-	Materials storage and handling at Darwin Port - Potential contamination to port marine waters from accidental releases. Existing Port authority environmental regulations at Darwin Port are adequate to mitigate, if not prevent, risks from unplanned accidents.	Yes

Environmental factor	Approved Project potential impacts	Proposed Project - key environmental factor status	Existing recommendations adequate
		Adequate upgrades and/or modifications of storage and handling facilities at the Darwin Port for the temporary under-cover storage of export fertilisers and imported sulphur will also be provided by Verdant.	
Communities and economy	Reduced access to land for traditional use by Aboriginal people -There is potential for the infrastructure corridor to restrict access to land used for traditional hunting and gathering practices of importance to Aboriginal people	No change from the Approved Project	Yes
	Changes to local socio-economic conditions	The Proposed Project has the potential to improve socio-economic conditions of the region. Potential socio-economic impacts assessed through social and economic impact assessment study.	Yes
Culture and heritage	Degradation of cultural values associated with sacred sites	No change from the Approved Project	Yes
	Degradation of cultural values associated with archaeological sites/artefacts	No change from the Approved Project	Yes
Human health	Implementation of the Proposal could result in potential impacts to human health via water, land, or air contamination, or through decreased community resilience.	No change from the Approved Project. Updated technical assessments including air quality dispersion modelling, noise modelling, groundwater modelling, surface water modelling, etc. indicated impacts are tolerable provided management measures are implemented.	Yes
Hydrological processes	Drawdown of shared aquifers to supply Proposed Project	Although additional water is planned for Proposed Project, impacts from drawdown of shared groundwater aquifers e.g., Hagen's bore and community water supplies (i.e., Ampilatwatja) are negligible. Therefore, no change from the Approved Project. Furthermore, Best Available Technology (BAT) throughout the design, including extensive water recycling, among other measures to significantly reduce overall potential water usage shall be applied.	Yes

Appendix C

EPBC Referral 2018



Approval

Ammaroo Phosphate Project, Northern Territory (EPBC 2014/7260)

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Proposed action

person to whom the approval is granted	Verdant Minerals Ltd
proponent's ACN	122 131 622
proposed action	To develop a phosphate mine, associated infrastructure and processing plant within the Ammaroo Pastoral Lease, and a transport and infrastructure corridor extending to the west of the Ammaroo Pastoral Lease, 270 km northeast of Alice Springs in the Northern Territory [See EPBC Act referral 2014/7260 as varied on 5 January 2018].

Approval decision

Controlling Provision	Decision
Listed threatened species and communities (sections 18 & 18A)	Approved

conditions of approval

This approval is subject to the conditions specified below.

expiry date of approval

This approval has effect until 31 December 2058.

Decision-maker

name and position	Gregory Manning Assistant Secretary Assessments (WA, SA, NT) and Post Approvals Branch
signature	
date of decision	19/6/18

Conditions attached to the approval

1. For the protection of **EPBC Act listed species** the approval holder must not **clear** more than 3775 hectares of land within the **project area**.
2. To mitigate and manage impacts to **EPBC Act listed species** the approval holder must undertake the following actions at any **open trench** within the **pipeline corridor**:
 - (a) install **trench plugs and ramps** at maximum intervals of 500 metres to enable fauna to escape from the pipeline trench
 - (b) install **fauna shelters** between the **trench plugs and ramps**, with a minimum of one **fauna shelter** every 500 metres, to provide daytime refuge or shelter to any fauna trapped in the trench
 - (c) engage a **fauna spotter** to undertake a daily inspection of the **open trench** to record the occurrence of **EPBC Act listed species** and translocate any surviving individuals to suitable habitat
 - (d) the length of each trench to be left open must not exceed the length capable of being inspected on foot and cleared by the designated **fauna spotter**.
3. Within 30 days after the **commencement** of the action, the approval holder must advise the **Department** in writing of the actual date of **commencement**.
4. The approval holder must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.
5. Within three months of every 12 month anniversary of the **commencement** of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** at the same time as the compliance report is published. Reports must remain published for the life of the approval. The approval holder must continue to publish reports annually until such time as agreed to in writing by the **Minister**. The compliance report must include, but is not limited to, the number and location of any **EPBC Act listed species** found within the **open trench** during the inspection required by Condition 2(c).
6. Upon the direction of the **Minister**, the approval holder must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the commencement of the audit. Audit criteria must be agreed to by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.
7. If, at any time after five (5) years from the date of this approval, the approval holder has not substantially **commenced** the action, then the approval holder must not substantially **commence** the action without the written agreement of the **Minister**.

Definitions

Clearing/clear means the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning of native vegetation.

Commencement is the construction of any infrastructure, excluding fences and signage, associated with the proposed action.

Department ('s) is the Australian Government Department or any other agency administering the **EPBC Act**.

EPBC Act is the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

EPBC Act listed species means the **EPBC Act** listed Greater Bilby (*Macrotis lagotis*) and Great Desert Skink (*Liopholis kintorei*).

Fauna shelters are structures designed to provide shelter for **EPBC Act listed species**

Fauna Spotter is a suitably qualified person(s) who can identify listed threatened species, give authoritative assessment, advice and analysis in relation to the humane capture, treatment, management and relocation of **EPBC Act listed species** using relevant protocols, standards, methods and literature.

Minister means the Minister administering the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and includes a delegate of the Minister.

Open trenches are excavations that have been dug but have not been back-filled.

Pipeline construction is the period of time when **open trenches** exist in the **pipeline corridor**.

Pipeline corridor is the area depicted as 'Access corridor and gas pipeline' between the 'purple' rail siding extending westward to the 'aqua' gas connect shown in Attachments A.

Project Area is the area shown in Attachment B, where it is depicted as '137 km natural gas supply pipeline', 'rail maintenance track', '105 km rail spur', 'borrow pit' and 'mineral lease', and marked with a 'solid green', 'solid pink', 'solid blue', 'patterned yellow' and 'red outline' respectively.

Trench plugs and ramps are barriers or exit points of ramped earth or artificial material placed within an **open trench** that will enable trapped animals to leave the **open trench**.

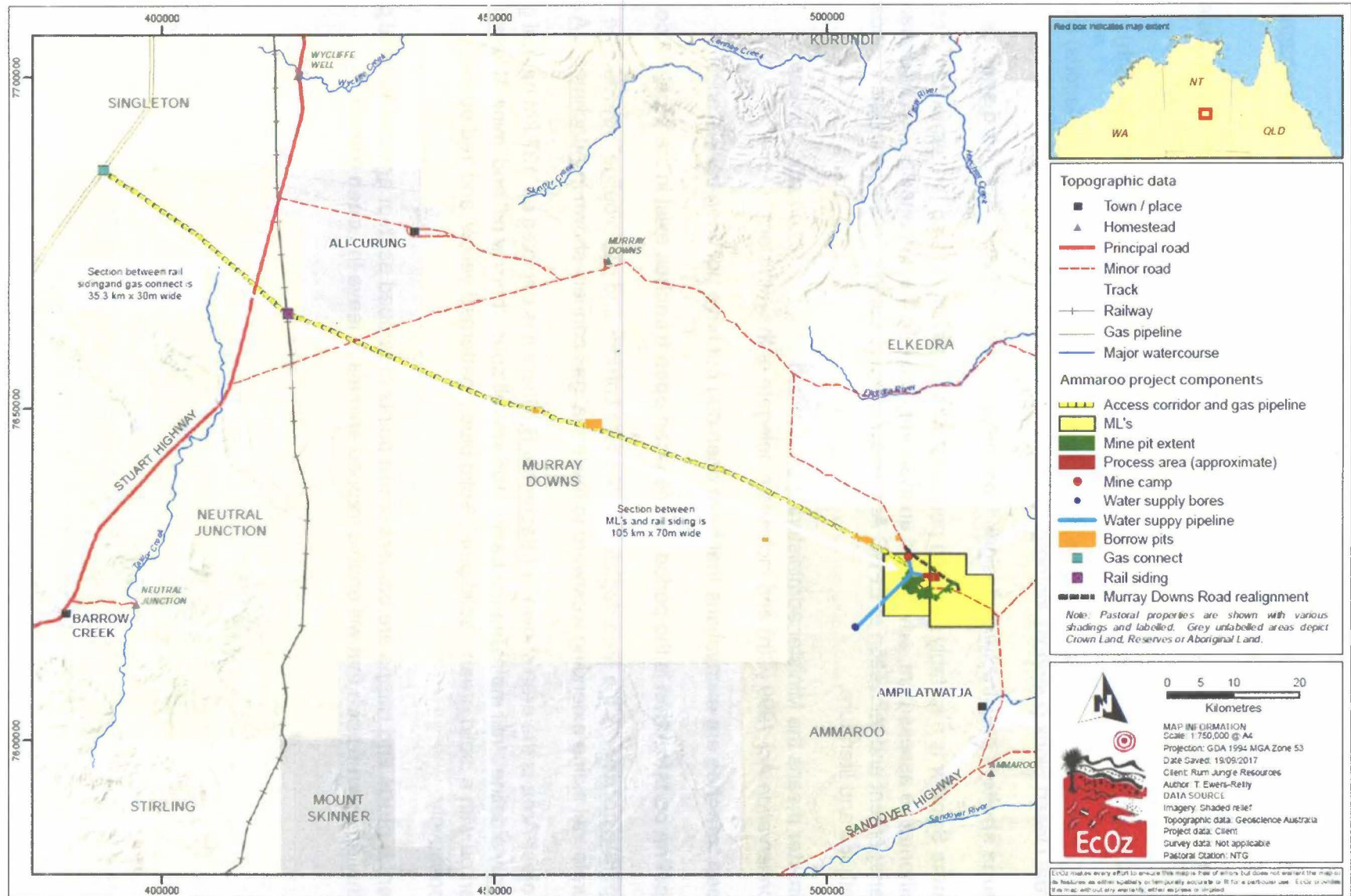
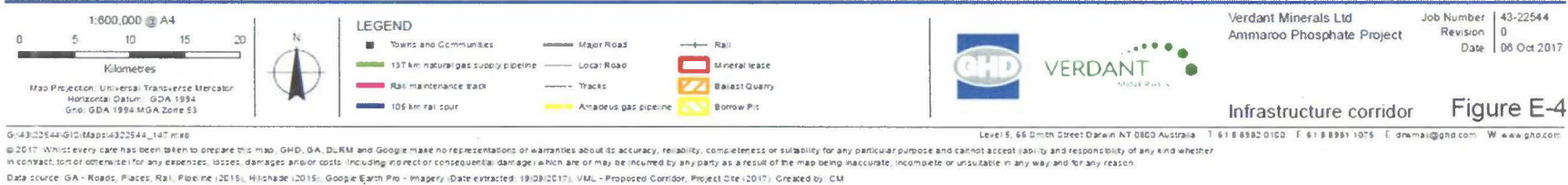
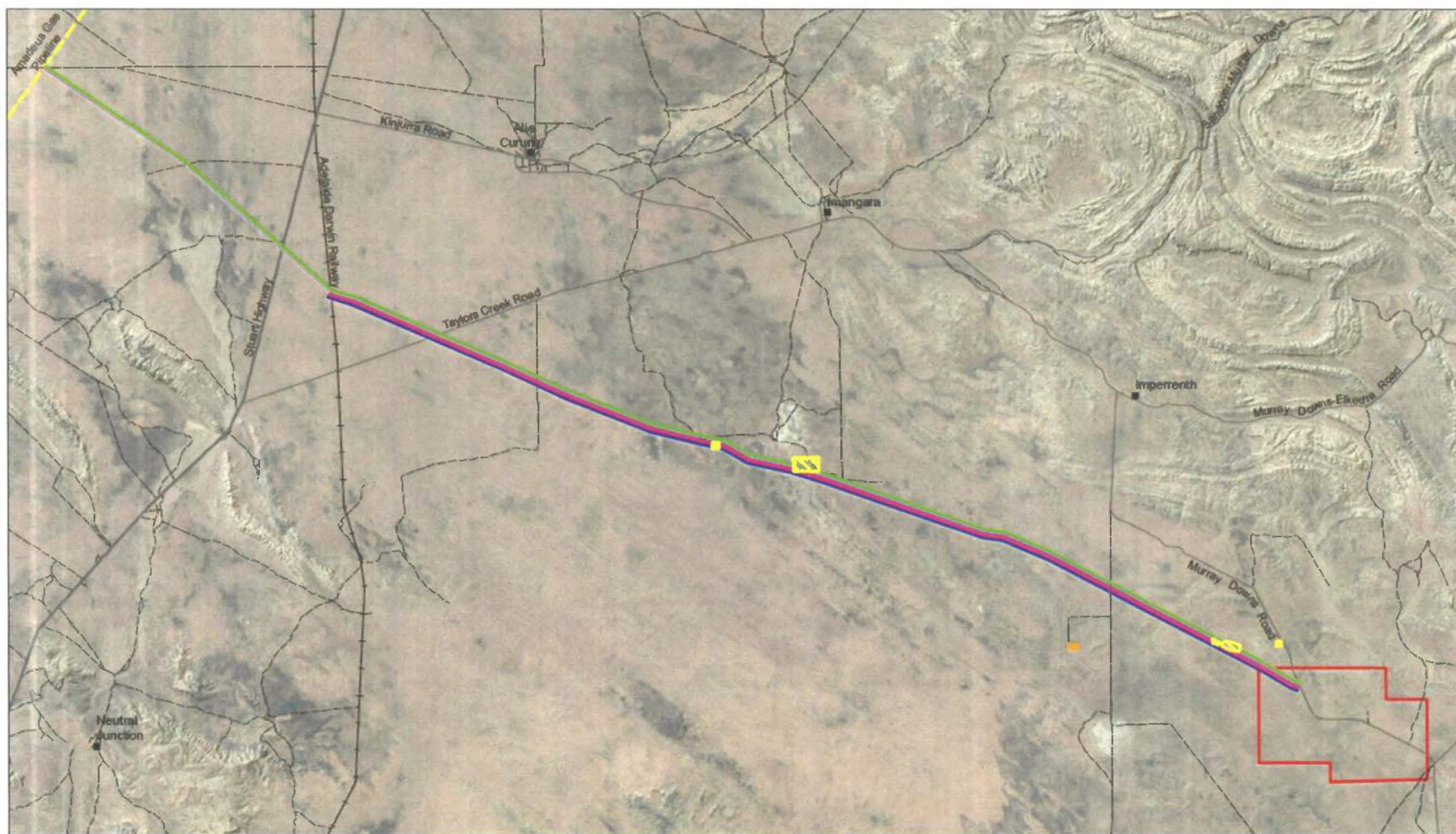


Figure 1-2. Map showing the main components of the Ammaroo Phosphate Project



Appendix D

NT EPA Assessment Report 87

ASSESSMENT REPORT 87

AMMAROO PHOSPHATE PROJECT Verdant Minerals Ltd

October 2018

Environmental Impact Assessment Process Timeline

Date	Chronology
24/04/2014	Notice of Intent received
19/06/2014	NT EPA decision issued - Environmental Impact Statement (EIS)
22/11/2014	Draft Terms of Reference (ToR) released for public comment
18/12/2014	Final ToR issued to proponent
28/10/2017	Draft EIS released for public comment for 6 weeks
20/12/2017	NT EPA direction to prepare EIS Supplement issued
2/08/2018	EIS Supplement received
2/10/2018	Assessment Report issued



Dr Paul Vogel
Chairman

2 October 2018

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Important Disclaimer

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Abbreviations and glossary

Advisory bodies	NTG Agencies having expertise and/or administrative responsibilities in respect of the Proposal
ADWG	Australian Drinking Water Guidelines
AMD	Acid and Metalliferous Drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
ASLP	Australian Standard Leaching Procedure
CHMP	Cultural Heritage Management Plan
DENR	Department of Environment and Natural Resources
Draft EIS	Draft Environmental Impact Statement
EA Act	<i>Environmental Assessment Act</i>
EAAP	Environmental Assessment Administrative Procedures
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement (made up of the draft EIS and the Supplement)
Environment	All aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects (Section 3 of the <i>Environmental Assessment Act</i>)
EP Act	<i>Energy Pipelines Act</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
ESCP	Erosion and Sediment Control Plan
ESIMP	Economic and Social Impact Management Plan
ESD	Ecologically Sustainable Development
FIFO	Fly-in / Fly-out
GHG	Greenhouse gas
MM Act	<i>Mining Management Act</i>
MCP	Mine Closure Plan
MMP	Mining Management Plan
NAF	Non-acid forming
NAG	Net acid generation

NOI	Notice of Intent
NORM	Naturally occurring radioactive materials
NTASS Act	<i>Northern Territory Aboriginal Sacred Sites Act</i>
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
ROM	Run of mine
SAR	Sodium absorption ratios
The Responsible Minister	Northern Territory Minister for Primary Industry and Resources
The Minister	Northern Territory Minister for Environment and Natural Resources
The Proposal	Ammaroo Phosphate Project
The Proponent	Verdant Minerals Ltd (formerly Rum Jungle Resources Ltd)
The Supplement	Supplement to the Draft EIS
The / this Report	Assessment Report 87, for the Ammaroo Phosphate Project
ToR	Terms of Reference

Units and symbols

%	percent
>/<	greater than/less than
°C	degrees Celsius
Bq/g	Becquerel per gram
GL	gigalitre (billion litres)
GL/y	gigalitre per year
ha	hectare
km	kilometre
L	litre
L/s	litres per second
m	metre
m ³	cubic metre
ML	megalitre (million litres)
mm	millimetre
mm/y	millimetres per year
mSv/y	millisievert per year
Mt	mega tonne (million tonnes)
Mt/y	mega tonne per year
MW	megawatt
MW/hr	megawatts per hour
P ₂ O ₅	Phosphorus pentoxide
PJ/y	peta joule per year
ppm	parts per million
kPa	kilopascal
t CO ₂ -e	tons of carbon dioxide equivalent

Summary and recommendations

Environmental impact assessment (EIA) is a process for identifying the potential environmental impacts and risks of a proposed action, evaluating the significance of those impacts and risks, and determining appropriate avoidance, minimisation and mitigation measures to reduce those impacts and risks to acceptable levels.

This Assessment Report (this Report) evaluates the environmental impacts and risks of the Ammaroo Phosphate Project (the Proposal), proposed by Verdant Minerals Ltd (the Proponent). This Report marks the end of the assessment process by the Northern Territory Environment Protection Authority (NT EPA).

The Report is provided to the Northern Territory Minister for Environment and Natural Resources (the Minister) and to the Minister for Primary Industry and Resources (the Responsible Minister) for approvals and conditioning that would be required for the Proposal under the *Mining Management Act* (MM Act) and any subsequent approvals. This Report is not intended to provide an environmental approval although it will guide the decision for authorisation (by the Responsible Minister).

The Proponent is proposing to develop and operate the Proposal, consisting of a phosphate mine and ancillary infrastructure, located in the Northern Territory (NT) approximately 220 km south-east of Tennant Creek and 270 km north-east of Alice Springs. The Proposal includes open-cut strip mining and on-site beneficiation producing up to 2 Mt/y of 32% phosphate rock concentrate over a 25 year mine life, targeting a portion of the known phosphate deposit in the area. This product would be transported by rail to the Port of Darwin for export.

The Proposal comprises:

- the mine site, including a processing plant and a surface tailings storage facility
- an infrastructure corridor accommodating a 105 km rail spur (connecting to the Adelaide to Darwin railway line) and a 137 km underground gas pipeline (connecting to the Amadeus gas pipeline)
- a bore field accessing the nearby Georgina Basin carbonate aquifer and a 12 km pipeline for water supply
- supporting infrastructure such as roads, a power station, an administration building and an accommodation village
- realignment of approximately 12 km of the Murray Downs Road (a public road) to bypass the mine site.

The Proposal would require clearing of approximately 3775 ha of native vegetation over the proposed 25 year mine life. Rehabilitation, including revegetation, would be progressive.

Based on the Notice of Intent, the NT EPA identified the following potential impacts and risks to the environment that may arise from implementation of the Proposal:

- impacts to users and groundwater dependent ecosystems as a result of groundwater drawdown from water abstraction
- contamination of surface waters, groundwater and soils
- impacts on biodiversity values and threatened species
- impacts to social, economic and cultural surroundings.

These potential impacts and risks contributed to the decision to assess the Proposal at the level of an Environmental Impact Statement (EIS).

In making this Report, the NT EPA had regard to the information provided by the Proponent, public submissions, specialist advice from advisory bodies across the NT Government, and relevant guidelines and standards. The NT EPA identified the following key environmental factors that may be significantly impacted by the Proposal:

- Hydrological processes
- Inland water environmental quality.

The Proposal is in an arid zone of Australia where water is a scarce and valuable resource, and the efficient use of surface and groundwater and the maintenance of water quality are of high importance. The proposed 3.6 GL/y of groundwater abstraction is substantial. This represents more than a third of the water abstracted to supply reticulated water to the town of Alice Springs, making the Proposal the second largest groundwater user in the region.

The Proponent's modelling predicts proposed water extraction from the nearby Georgina Basin carbonate aquifer will result in groundwater drawdown that could reduce the availability of water to other users in the long term.

To ensure groundwater drawdown is appropriately managed, the NT EPA recommends the development of a Water Abstraction Management Plan (WAMP) separate to a Water Management Plan. The WAMP should focus on issues associated with the management of groundwater abstraction and the monitoring of groundwater hydrology. Complementary to the WAMP, the Water Management Plan should focus on all other issues associated with water use on the Proposal site, operational water management and water quality.

The Proponent committed to ensuring that there will be no reduction in water availability to other users because of mining and presented a range of monitoring and mitigation measures to address potential impacts to other users of groundwater. In order to further mitigate and manage the potential impacts, the NT EPA recommends that all recommendations from the peer review and commitments made by the proponent are incorporated into the WAMP, that groundwater levels at nearby stock and community bores are monitored and that hydrological baseline data are established for all groundwater abstraction monitoring bores.

The NT EPA recommends further transparency for managing groundwater abstraction, including consultation with stakeholders on the Proponent's use of groundwater. The NT EPA also recommends that the Proponent demonstrates continual improvement in water use efficiency to minimise groundwater abstraction and best practice water management in line with the International Council on Mining and Metals water stewardship framework (ICMM 2014). This would include implementation of a WAMP and being publicly accountable through public disclosure of the WAMP, the WMP and annual Water Management Reports.

The Proponent's investigations indicated it is unlikely that saline drainage, and acid and metalliferous drainage (AMD) would be generated from mined and processed materials, and that any leachate is unlikely to significantly impact on groundwater and surface water quality. Initial chemical assays indicated that the waste rock is low in sulfur and potentially toxic metals and is non-acid forming, typical of highly oxidised and weathered material above the long-term water table.

Nevertheless, the NT EPA recommends that the proposed tailings leachate seepage monitoring and mitigation program should be implemented as a precautionary measure, recognising that further characterisation of tailings and waste rock geochemistry will continue to inform knowledge of the composition of seepage. The NT EPA recommends that all learnings be used to improve the existing hydrogeological model for the mine site, and the findings reported in the annual Water Management Report. In order to

ensure the seepage monitoring program is appropriate and scientifically robust, NT EPA recommends an independent external audit of the program should be undertaken after four and ten years of tailings deposition.

There are no surface water features within the proposed mine site. The primary pathway for potential contamination of surface waters downgradient of the mine site would be through an accidental spill or an uncontrolled discharge. The NT EPA assessed the risk of these as low with the implementation of the proposed preventative measures, monitoring programs and contingency plans.

The NT EPA supports the Proponent's commitment for progressive rehabilitation as a key feature of their conceptual mine closure plan. In order to ensure best practice is applied to rehabilitation and that revegetation is developing towards self-sustaining ecosystems, the NT EPA recommends an independent external audit is undertaken of rehabilitation, including revegetation, every five years and at closure. The NT EPA has made recommendations to ensure that mine closure planning is thoroughly considered prior to authorisation of the Proposal and on an ongoing basis throughout the mine life, including appropriate stakeholder consultation and an agreed post-mining land use. The NT EPA expects the learnings from research, site investigations and rehabilitation monitoring to be integrated into progressive updates of the Mine Closure Plan.

The NT EPA has made 12 recommendations as an outcome of the EIA of the Proposal. These recommendations are primarily for the Proponent to address through the approval process and during the implementation of the proposed action.

The NT EPA emphasises that the environmental commitments, safeguards and recommendations outlined in the EIS, this Assessment Report and in the final management plans, must be implemented by the Proponent and oversighted and enforced by the relevant regulator throughout the life of the Proposal to deliver acceptable environmental outcomes.

The NT EPA considers that, subject to the implementation of the recommendations and the Proponent's commitments, the Proposal can be managed in a manner that is likely to meet the NT EPA's objectives and avoid significant or unacceptable environmental impacts and risks.

List of recommendations

Recommendation 1

That the Proponent ensures that the Ammaroo Phosphate Project is implemented in accordance with all environmental commitments and safeguards:

- identified in the final Environmental Impact Statement for the Ammaroo Phosphate Project (draft Environmental Impact Statement and Supplement to the draft Environmental Impact Statement)
- recommended in this Assessment Report 87
- to the satisfaction of the relevant regulator.

The Northern Territory Environment Protection Authority considers that all safeguards and mitigation measures outlined in the Environmental Impact Statement are binding commitments made by the Proponent.

Recommendation 2

That the Proponent provide written notice to the Northern Territory Environment Protection Authority and the Responsible Minister if it alters the Ammaroo Phosphate Project and/or commitments, safeguards or mitigation measures in the Environmental Impact Statement in such a manner that the environmental significance of the action may have changed, in accordance with clause 14A of the Environmental Assessment Administrative Procedures.

Recommendation 3

That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Water Abstraction Management Plan to the relevant regulator prior to mining that:

- includes a framework identifying the location, timing, methods and parameters for the collection of further groundwater information
- incorporates the recommendations of the independent peer review to improve identification of natural recharge processes and extraction rates of other users; characterisation of flow and flow directions; and robustness of the water level baseline by capturing seasonal changes
- incorporates a program to monitor groundwater levels at nearby stock and community bores
- is based on robust groundwater level baseline data capturing seasonal changes over at least 12 months at all proposed groundwater abstraction monitoring bores, including borefield and nearby stock and community bores
- incorporates all relevant commitments made by the Proponent in the Environmental Impact Statement, including a zero reduction in water availability to other users from mining activities
- is developed in consultation with relevant stakeholders, including other groundwater users

- actively and continuously seeks to improve knowledge of aquifers and groundwater tables affected by the Proposal and incorporates these into the model
- is independently peer reviewed by a suitably qualified independent professional
- is developed and implemented to the satisfaction of the relevant regulator
- is to be updated at least annually
- reports all water monitoring data with an assessment of the impacts on groundwater hydrology in an annual Water Management Report.

Public disclosure of the annual Water Management Report and each updated Water Abstraction Management Plan should be provided on the websites of (as applicable) the Proponent, the Operator and relevant authorities.

Recommendation 4

That approvals and decisions for the Proposal have conditions that require the Proponent to:

- allocate clear responsibilities and accountabilities for water use and management
- provide regular updates of the projected water balance for the Proposal in the Water Management Plan, including detailed estimates for the various phases of the Proposal and specifying the source and quantity of the water to be used
- demonstrate how water saving considerations are integrated in Proposal planning including final design and technologies
- report on continual improvement initiatives in water use efficiency including the provision of relevant water use targets
- provide details on how water will be effectively managed during proposed operations, including minimising water consumption, maximising water reuse and minimising waste water
- abstract water from bores only when equipped with operating flow meters
- record the volume of water abstracted from the borefield and the corridor construction bores
- report water use performance in relation to target, and any change to targets in an annual Water Management Report to stakeholders

Public disclosure of the Water Management Plan and annual Water Management Report should be provided on the websites of (as applicable), the Proponent and relevant regulatory authorities.

Recommendation 5

That approvals and decisions for the Proposal have conditions that require the Proponent to:

- update the seepage monitoring program in the Water Management Plan to include recommendations of the peer review
- annually review and, if required, update the seepage model.

Findings of the review and updates should be reported in the annual Water Management Report.

Recommendation 6

That approvals and decisions for the Proposal have conditions that require the Proponent to provide an updated Acid and Metalliferous Drainage Management Plan to the relevant regulator prior to mining that:

- incorporates the recommendations of the independent peer review and all commitments made by the Proponent in the Environmental Impact Statement including further testing in the pre-production phase (geochemical testing of tailings and ore, identification of suitable capping/encapsulation material and additional NAG and NAPP testing)
- includes aggressive leach testing of tailings prior to mining with the results to be reported to the relevant regulator for assessment and, if required, identification of appropriate mitigation measures
- incorporates a program to analyse in-situ extracts of tailings seepage and decant water during the first 12 months of operation with the results to be reported to the relevant regulator for assessment and, if the seepage composition exceeds the agreed threshold levels, then mitigation options such as lining the tailings storage or additional tailings treatment must be implemented immediately
- includes a program for regular geochemical testing of all materials scheduled for mining or in constructed landforms (including ore stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested
- includes a contingency plan outlining trigger levels for actions, specific responses and mitigation measures, and consequences for operational, rehabilitation and closure activities.

The Acid and Metalliferous Drainage Management Plan should be developed and implemented to the satisfaction of the relevant regulator.

Recommendation 7

That the Acid and Metalliferous Drainage Management Plan, referenced at Recommendation 6, include a program for regular radiological testing of all materials scheduled for mining or in constructed landforms (including ore stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested.

Recommendation 8

That approvals and decisions for the Proposal have conditions that require the Proponent to develop a Water Management Plan to the satisfaction of the relevant regulator prior to mining. The plan should include:

- an assessment of chemicals added during water treatment and the beneficiation process, including an assessment of their behaviour and breakdown products in tailings and tailings decant/seepage and potential to contaminate the environment. In particular:
 - clearly identifying the type of polyacrylamide and polymer flocculants
 - polyacrylamides with more than 0.05% of the neuro-toxin acrylamide monomer are not to be used
- recommendations of the independent peer review to monitor seepage during the early stages of mine development
- robust pre-mining groundwater quality baselines to be used as trigger levels for mitigation measures, or should no groundwater be present, livestock drinking water guidelines to be used as trigger thresholds
- in line with the program to monitor potential contamination sources (Recommendation 6) potential contaminant concentrations in waste rock and tailings leachate should be identified and used as trigger thresholds for management actions to mitigate the source of contamination
- contingency measures to mitigate the source of contamination, if trigger values are exceeded
- a robust groundwater quality monitoring program that can quantify the extent and quality of any potential seepage from the proposed mine site
- a requirement for an independent external audit of the seepage monitoring program by a suitably qualified and experienced professional after four and ten years of tailings deposition. The auditor is to report to the relevant regulator.

All water quality monitoring data, trigger values, audit reports and an assessment of impacts should be made publicly available in an annual Water Management Report on the websites of (as applicable) the Proponent, the Operator and relevant regulatory authorities.

Recommendation 9

That the Proponent rehabilitate and revegetate all sections of the infrastructure corridor not required during the operational phase shortly after construction has been completed. Revegetation is to use local native plant species.

Recommendation 10

That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Mine Closure Plan to the relevant regulator prior to mining. The Mine Closure Plan must:

- be of a standard equal to or better than the Western Australian guidelines for preparing mine closure plans (DMP, 2015)
- address all aspects of rehabilitation and mine closure, including post-mining land use agreed with stakeholders, rehabilitation objectives, schedules for progressive rehabilitation, completion criteria and monitoring of rehabilitation success
- include predicted landform designs that are consistent with current standards and best practice
- include plans and a schedule for post-construction rehabilitation of all areas of the infrastructure corridor that would no longer be required after construction
- demonstrate that all rehabilitated areas would be safe to humans and animals, geotechnically stable, non-polluting and non-contaminating, and capable of sustaining the agreed post-mining land use
- include details of the research trials and investigations that would inform, guide and support appropriate landform covers and ecosystems for all rehabilitation, including progressive rehabilitation and closure
- investigate the long term settling process of tailings and waste rock to inform construction of appropriate landform covers and avoidance of significant depressions and pooling of water
- provide details of a program for regular monitoring and reporting on the performance of progressive rehabilitation works
- provide for results from monitoring the performance of progressive rehabilitation to inform decision-making to ensure long-term successful rehabilitation
- outline a strategy for appropriate consultation with stakeholders on rehabilitation objectives and post-mining land use
- provide for ongoing monitoring and maintenance of the site post-mining, in accordance with an approved monitoring and maintenance program, until such time as the relevant regulator directs
- require reporting to the relevant regulator on progressive rehabilitation works and performance
- require independent external audits by suitably qualified and experienced professionals of the progressive rehabilitation, including revegetation, at least every five years and at closure.

The Mine Closure Plan is to be peer-reviewed by an appropriately qualified independent professional prior to submission to the relevant regulator.

Recommendation 11

That approvals and decisions for the Proposal have conditions that require future iterations of the Mine Closure Plan to include:

- alternative rehabilitation options that identify a range of closure scenarios and strategies for the mine pit and associated infrastructure and provide justification that the preferred closure option minimises environmental risks
- identification and management of knowledge gaps relating to closure-specific technical information (including environmental baseline data, waste characterisation, and review of monitoring data) to inform sustainable mine closure
- details of pre-closure research trials, investigations and modelling aimed at addressing knowledge gaps to inform detailed rehabilitation design. These are to include, but are not limited to, vegetation, final cover materials, capping design, and surface water runoff.

Recommendation 12

That approvals and decisions for the Proposal include conditions that require the Proponent to demonstrate appropriate engagement with native-title holders, and to establish a Community Consultation Group with Aboriginal, pastoral, and other relevant stakeholders to provide a forum to:

- inform (in an appropriate manner) local residents of key aspects of the Proposal that may impact on their values, including amenity and cultural practices
- consult with local residents and relevant agencies on matters relating to the proposed workforce, to maximise benefits for local employment, and to manage cumulative impacts on demand for local workers and overall employment opportunities
- undertake ongoing stakeholder consultations on agreed post-mining land use and rehabilitation objectives.

1 Introduction

1.1 Purpose of this Report

Verdant Minerals Ltd (the Proponent) proposes to develop and operate the Ammaroo Phosphate Project (the Proposal), comprising a phosphate mine and ancillary infrastructure.

The Proposal has been assessed by the Northern Territory Environment Protection Authority (NT EPA) at the level of an Environmental Impact Statement (EIS) under the *Environmental Assessment Act* (EA Act). The NT EPA has prepared this Assessment Report (this Report) in accordance with section 7(2)(g) of the EA Act and clause 14(3) of the Environmental Assessment Administrative Procedures (EAAP).

The purpose of this Report is to ensure that matters with the potential to affect the environment to a significant extent are fully examined and reported. This Report is provided to the Northern Territory Minister for Environment and Natural Resources (the Minister) who will provide the report to the Minister for Primary Industry and Resources (the Responsible Minister) to be taken into account in decisions made by the Northern Territory (NT) Government.

This Report it is not intended to provide an environmental approval although it will guide the decisions and conditions of approvals, authorisations and other matters.

1.2 Scope of the assessment

The NT EPA assessed the potentially significant environmental impacts and risks associated with the Proposal in line with the NT EPA's environmental factors and objectives and in accordance with the requirements of the EA Act. The matters relating to the environment that the NT EPA considered necessary to be dealt with in the EIS for the Proposal were identified in the Terms of Reference (NT EPA, 2014 b), which were developed in accordance with clauses 8(3) to (6) of the EAAP.

Based on the Notice of Intent, the NT EPA identified the following potential environmental impacts and risk categories that contributed to the decision to assess the Proposal at the level of an EIS:

- uncertainty of proposal configuration
- impacts to users and groundwater dependent ecosystems resulting from groundwater drawdown from water abstraction
- contamination of surface waters, groundwater and soils
- impacts on biodiversity values and threatened species
- impacts to social, economic and cultural surroundings.

1.3 Information before the NT EPA

In making this report, the NT EPA had regard to:

- the Notice of Intent
- the Terms of Reference
- the Draft EIS
- the Supplement to the Draft EIS
- comments from NT Government agencies on the draft Terms of Reference, Draft EIS and Supplement to the Draft EIS

- comments from the public on the draft Terms of Reference and Draft EIS
- technical and other reports and guidelines that are noted in the References (section 7) to this Report.

1.4 Regulatory framework

The Proposal will require approval and regulation by the NT and Australian governments. The framework for approval and regulation of the Proposal is provided at Chapter 3 of the Draft EIS and is summarised below, with an emphasis on the obligations and requirements of the NT Government.

The NT EPA provides this Report to the Minister. The Minister is required to provide a copy of this Report to the Responsible Minister, together with any written comments made by the Minister in relation to this Report. If the Minister makes a comment in relation to this Report, the Minister must comply with reporting obligations to the NT EPA, under section 8B of the EA Act.

1.4.1 Primary approval

The *Mining Management Act* (MM Act) is the primary legislation for the authorisation of mining activities and the regulation of mining sites in the Territory. The Responsible Minister, taking into consideration this Report, will decide whether to grant an authorisation under the MM Act and the conditions that may be applied.

Section 8A(2) of the EA Act requires the Responsible Minister to give the NT EPA notice of the decision as soon as practicable, but within seven days, after making the decision. Alternatively, if the decision by the Responsible Minister is contrary to this Report, the Responsible Minister must comply with reporting obligations to the NT EPA and the Legislative Assembly in accordance with section 8A(3) of the EA Act.

The provision of this Report to the Minister marks the completion of the examination of the EIS by the NT EPA. The EIS and supporting documents can be viewed on the NT EPA website at: <https://ntepa.nt.gov.au/environmental-assessments/register/ammaroo-phosphate-project>.

1.4.2 Other approvals

The proposed gas pipeline will require an energy pipeline licence under the *Energy Pipelines Act* (EP Act) if pressures will exceed 1050 kPa. The EP Act is the primary legislation for the construction, operation, maintenance and cessation of use or abandonment of pipelines for the conveyance of energy-producing hydrocarbons, and for related purposes, in the Territory.

1.4.3 Environment Protection and Biodiversity Conservation Act 1999

In 2014 the Australian Government Minister for the Environment determined that the Proposal was a controlled action and required assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) at the level of Preliminary Documentation under section 95A of the EPBC Act. As no bilateral agreement between the NTG and the Australian Government was in place at the time, the Proposal was assessed separately by the Australian Government Minister for the Environment and Energy. Approval was granted under the EPBC Act on 14 May 2018 subject to seven conditions (DoEE, 2018).

2 The Proposal

2.1 Proponent

The Proponent is Verdant Minerals Ltd (formerly Rum Jungle Resources Ltd), an Australian company listed on the Australian Securities Exchange. The Proponent's portfolio includes the Karinga Lakes Potash Project and the Patanella Phosphate Project.

The Proponent has been actively exploring for phosphate in the area since 2009. It considers the Ammaroo deposit to be the largest undeveloped Joint Ore Reserves Committee-compliant rock phosphate resource in Australia.

2.2 Proposal description

The Proposal consists of three main activities:

- open-cut strip mining of shallow phosphate deposits of up to 25 Mt/y
- beneficiation and production of up to 2 Mt/y of 32% P₂O₅ phosphate rock concentrate
- transport of phosphate rock concentrate via rail to Port of Darwin for export to international markets.

The infrastructure of the Proposal comprises:

- the mine site, including open-cut pits, a processing plant and a surface tailings storage facility (surface TSF)
- an infrastructure corridor accommodating a 105 km rail spur (connecting to the Adelaide to Darwin railway line) and a 137 km underground gas pipeline (connecting to the Amadeus gas pipeline)
- a borefield and a 12 km pipeline for water supply
- supporting infrastructure such as roads, a power station and an accommodation village
- realignment of approximately 12 km of the Murray Downs Road to bypass the mine site.

A detailed description of the Proposal is presented in Chapter 2 of the Draft EIS.

2.2.1 Location

The Proposal is located in the Northern Territory approximately 220 km south-east of Tennant Creek and 270 km north-east of Alice Springs (Figure 1). The closest settlement to the mineral leases is the community of Ampilatwatja, approximately 12 km to the south-east. The closest settlements to the infrastructure corridor are the community of Ali Curung and outstations at Impererenth and Imangara, approximately 17 to 25 km to the north. The geographic coordinates of the Proposal are presented in Appendix 1.

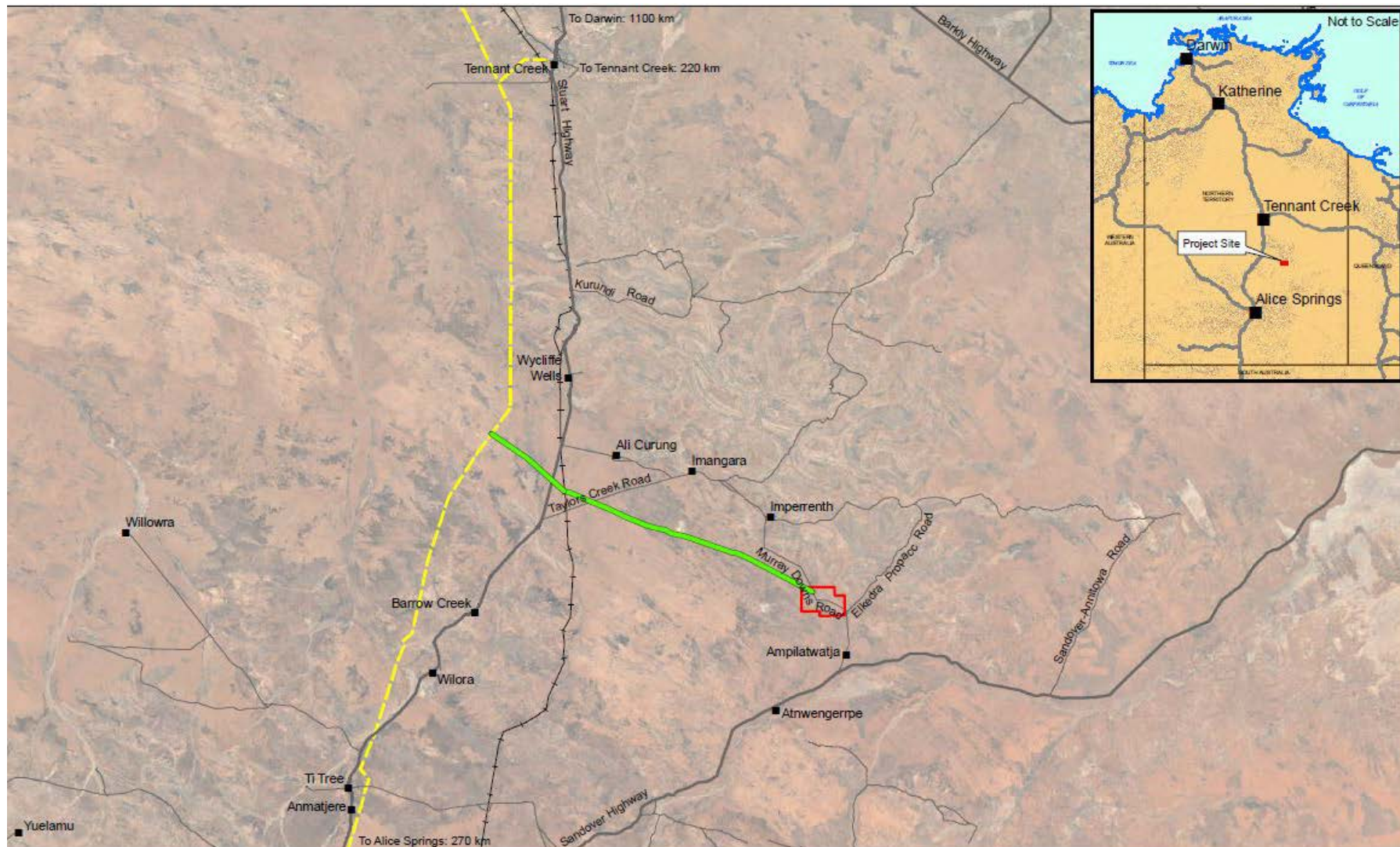


Figure 1. Ammaroo Phosphate Proposal location. Legend: mineral lease (red), access corridor (green), Amadeus gas pipeline (yellow), roads (grey). Source: Draft EIS.

2.2.2 Regional context

The climate is arid with infrequent and unpredictable rainfall, wide temperature extremes and low average humidity. Although the mean annual rainfall is about 315 mm and mostly associated with the summer months, there is high variability and extended periods with minimal rainfall. The area has high summer maximum temperatures (average 37°C) and low minimum winter temperatures (average 8°C). Sub-zero temperatures occur occasionally during July and August with frosts and surface water freezing at night. Annual pan evaporation is almost ten times higher than annual rainfall.

Regional topography is dominated by the Davenport and Murchison Ranges. The ranges are located approximately 15 km north of the proposed mine site and form a large system of rugged rocky hills rising approximately 100 m above the surrounding plains. Within the ranges, sheltered gorges support permanent and near-permanent waterholes. The ranges are bounded to the west and south by the Tanami bioregion which consists mainly of relatively featureless sand plains with small areas of alluvial plains, low ridges and stony rises. The entire Proposal falls within the Tanami bioregion.

After heavy rain events, ephemeral streams flow from the ranges onto the plains and flood out rather than feed into other major drainage features. The eastern portion of the proposed mine site generally drains to the south-east towards the Sandover River. The western side, including the infrastructure corridor, generally drains to the west and north-west towards Thring Swamp. During intense rain events, out-of-bank flow occurs as sheet wash, leading to short-term flooding.

The current land use at the proposed mine site and surrounding areas is cattle grazing, and the proposed mine site is situated on the Ammaroo pastoral lease. The proposed infrastructure corridor traverses the Ammaroo, Murray Downs and Neutral Junction pastoral leases.

The area surrounding the Proposal is sparsely populated with communities, outstations and homesteads that are serviced by the regional towns of Tennant Creek, Ti Tree and Alice Springs. Water for domestic and stock use is sourced from the Georgina Basin carbonate aquifer. Four wheel drive tourists following the Binns Track to access the Iltwelepenty/Davenport Ranges National Park travel along Murray Downs Road past the proposed mine site.

Existing infrastructure in the broader region includes the Amadeus Gas Pipeline, Northern Gas Pipeline, Austral-Asia Railway and the Stuart Highway.

There are also a number of proposed developments in the region at various stages of planning, including Chandler Facility (salt mine and waste storage), Nolans Project (rare earth elements mine), Mount Peake Project (titanium, vanadium, iron mine), Molyhil (tungsten and molybdenum), Bigryli (uranium) and Jervois Base Metal Project (copper and other base metals mine) (Figure 2).

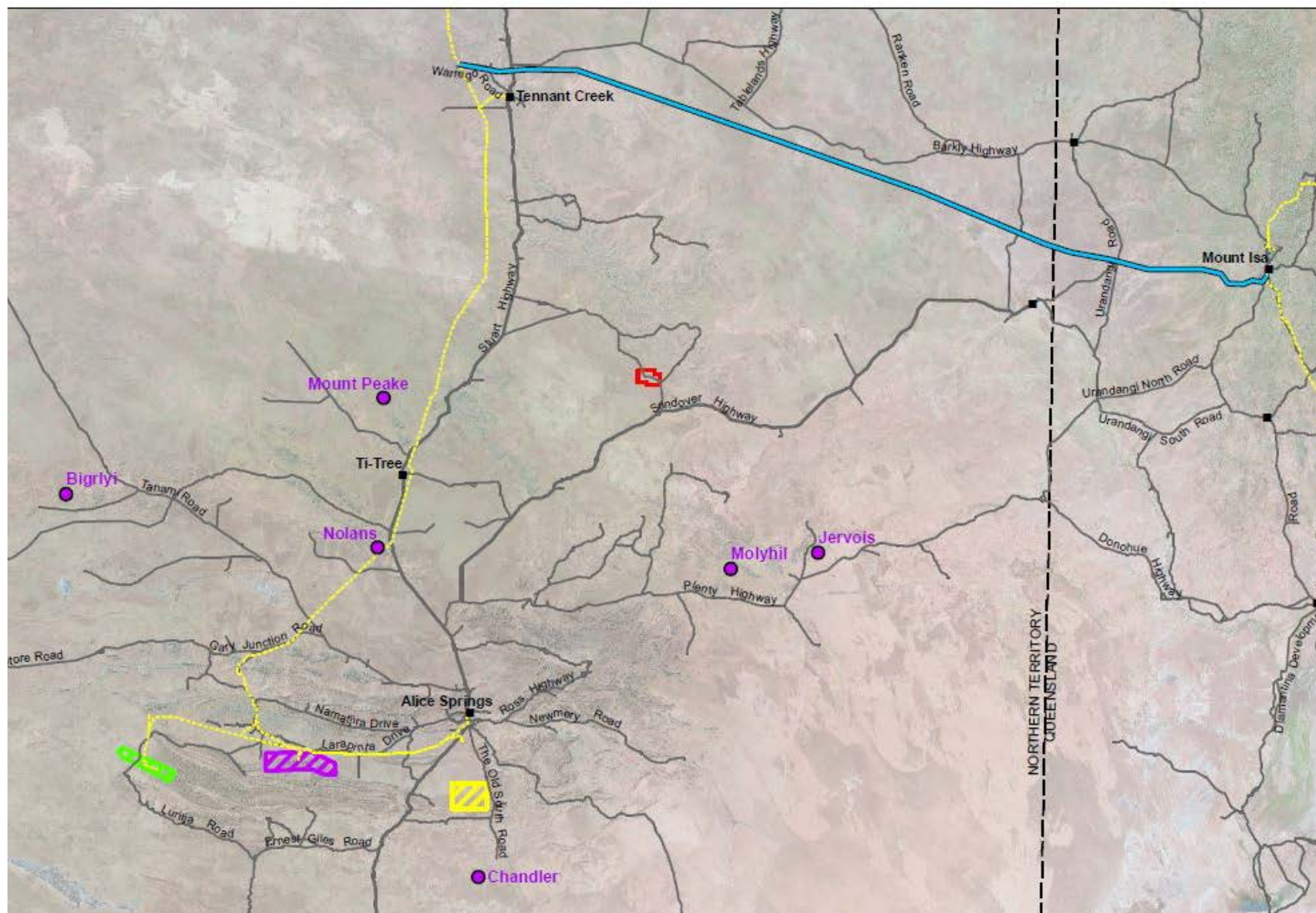


Figure 2. Other developments and infrastructure in the region. Legend: mineral lease (red), Dingo gas field (yellow hatched), Palm Valley Gas Field (purple hatched), Amadeus gas pipeline (yellow), Mereenie oil gas field (green hatched), Northern pipeline project (blue), roads (grey). Source: Draft EIS.

2.2.3 Overview of components

The Proposal footprint covers four areas: the mine site; the bore field and water pipeline; the infrastructure corridor; and the realignment of Murray Downs Road (Figure 3 and Figure 4).

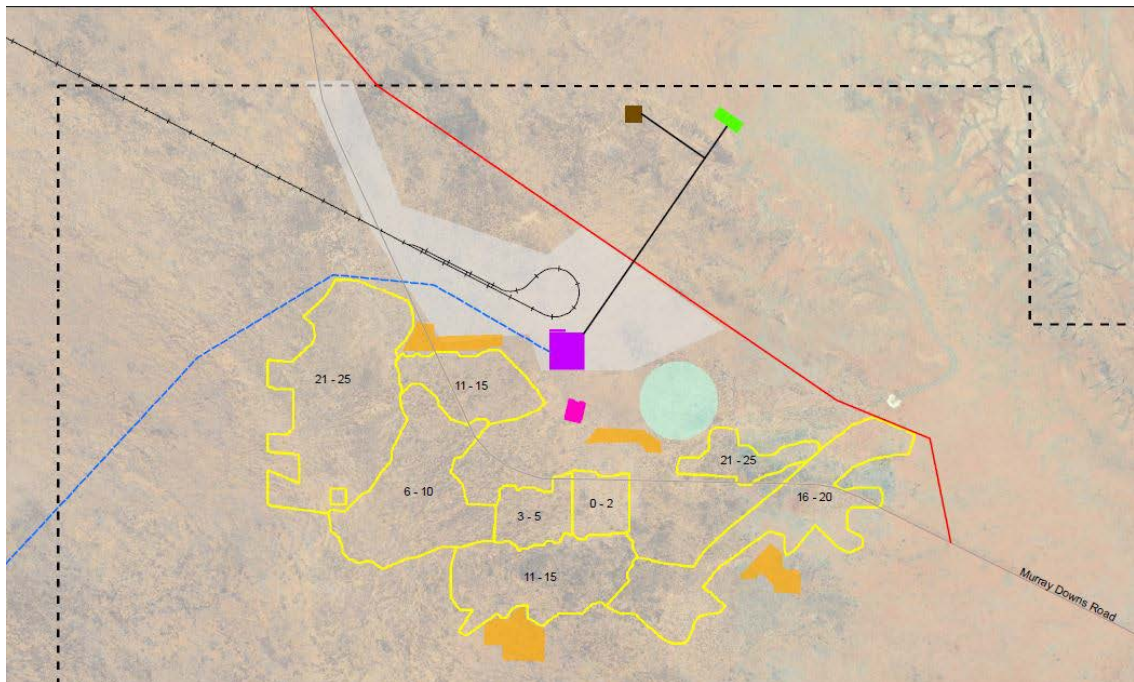


Figure 3. Mine site layout. Legend: beneficiation plant (purple), ROM (pink), pit with proposed mining years (yellow), surface TSF (light cyan), accommodation camp (green), landfill (brown), temporary waste rock stockpiles (orange), road alignment (red), water supply pipeline (blue), access corridor (black), mineral lease (black). Source: Draft EIS.

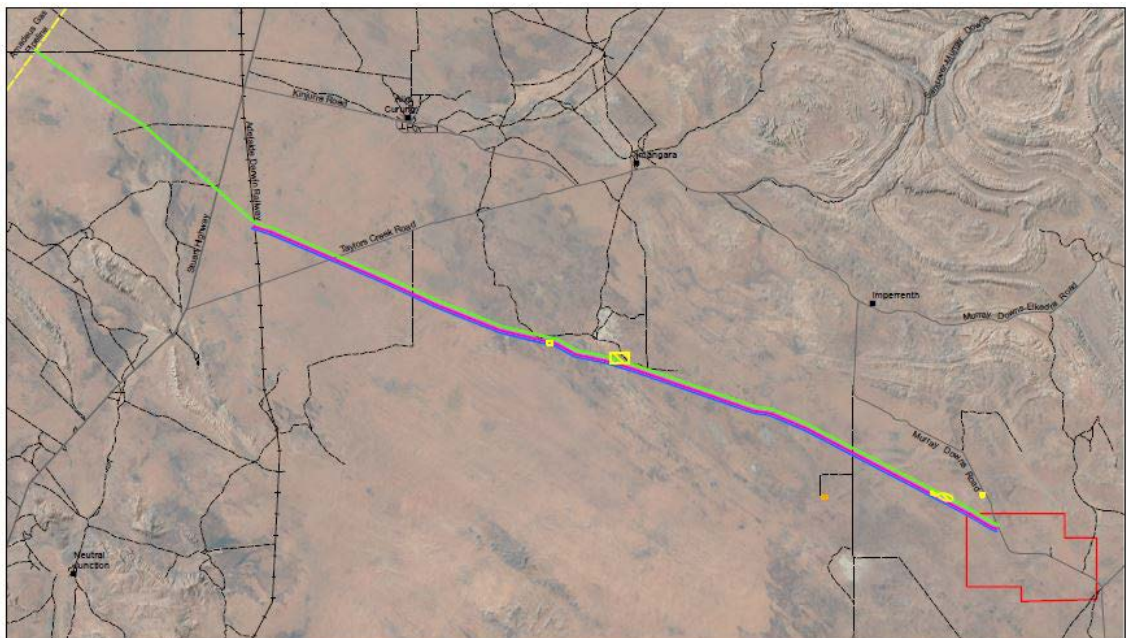


Figure 4. Infrastructure corridor layout. Legend: mineral lease (red), gas pipeline (green), rail spur (blue), maintenance track (pink), Amadeus gas pipeline (yellow), ballast quarry (orange), borrow pit (yellow hatched), roads and tracks (grey). Source: Draft EIS.

The components of the Proposal are summarised in Table 1.

Table 1: Key components and footprint of the Proposal.

	Component	Size/capacity
Whole of proposal	Maximum area of disturbance over 25 year mine life	3775 ha
	Life of mine (LOM)	25 years
	Construction period (included in LOM)	(2 years)
	Rehabilitation	progressive
	Final rehabilitation and closure	2 years
Mine site	Open pit (23 m average depth, 60 m maximum depth)	1500 ha
	Surface TSF	90 ha 3 m high 530 m radius
Mine infrastructure	Processing plant, power station, accommodation village, administration buildings and other ancillary infrastructure	650 ha
	Gas-fired power station	24 000 kW
	Fuel storage facility	417 t
Water supply - mining	A new borefield accessing the Georgina Basin carbonate aquifer	3+ bores 38 L/s per bore
	Water pipeline, including maintenance track	12 km
	Total annual abstraction (for 2 Mt/y P ₂ O ₅ production)	3.6 GL/y
Workforce	Operational:	165 workers
	Construction:	up to 300 workers
Other infrastructure	105 km infrastructure corridor (including rail, rail loop at mine site, maintenance track and low pressure gas pipeline) with a width of 70 m during construction and 50 m during operation.	800 ha
	32 km additional gas pipeline, beyond railway corridor (gas pipeline - 137 km in total)	115 ha
	Borrow pits (5 pits and access tracks)	550 ha
	Murray Downs Road alignment, approx.12 km	50 ha
	Total area of corridor disturbance	1515 ha

2.2.4 Construction

The construction period for mine infrastructure is expected to be up to two years, with processing to start in year one. Construction during the pre-production phase would focus on essential infrastructure required for mining such as haul roads, water production wells and pipeline, Murray Downs Road realignment and sufficient ore feed stock for commissioning of the processing plant. Suitable overburden from the pits would be used in the construction of infrastructure such as road bases, foundation pads, tailings dam embankments, surface water diversion berms. Construction materials for Murray Downs Road would be sourced locally.

A 137 km long underground, low pressure, carbon fibre gas pipeline is proposed to supply gas from the Amadeus gas pipeline to the proposed mine. The pipeline will be installed using “Mole Ploughing” whereby a temporary trench of approximately 350 mm width and 1050 mm depth will be ploughed, while at the same time a 5 inch diameter carbon fibre pipeline will be rolled off a spool and laid at the bottom of the temporary trench. Hydrostatic testing of the pipeline will be conducted in accordance with Australian Pipeline Industry Association’s Code of Environmental Practice: Onshore Pipelines (APGA, 2017) and an approved Hydrostatic Testing Management Plan. A maximum of 1.4 ML of water with no additives will be required. It is proposed to dispose of the hydrostatic test water in the process water ponds at the proposed mine site.

A 105 km rail line would be constructed to the mine site from the main Adelaide to Darwin railway. The rail line will cross Taylors Creek Road, pastoral tracks and stock crossings. Construction of level crossings ('at grade' crossings) using passive controls (e.g. stop or give way signs) is proposed. The rail embankment would be constructed to withstand a 25 year average recurrence interval (ARI) flood event. Culverts would be installed to manage surface water flows and scour protection would consist of placed rock (rip-rap).

Water for the construction of infrastructure on the mine site would be sourced from the mine's borefield 12 km south-west of the mine site.

Water for the construction of the infrastructure corridor would be sourced from existing local bores and four new bores constructed approximately every 20 km along the corridor.

Potable water for consumption and camp use will be supplied by tanker.

Access to the Proposal site is from the Stuart Highway via the unsealed Sandover Highway and Murray Downs Road from the south, or via the unsealed Murray Downs Road (via Kinjurra Road) from the north. A realignment of approximately 12 km of the Murray Downs Road is proposed to avoid the mine site. Traffic between the mine site and the accommodation camp would need to cross Murray Downs Road.

Light vehicle traffic includes movement of construction workforce and service vehicles supplying accommodation camps. The Proponent assumes the majority (85%) of light vehicle traffic would originate from the south (Alice Springs) and anticipates 34 vehicle trips per week. Heavy vehicles would be required to transport plant, equipment and materials. The Proponent expects the majority (70%) would originate from the north (Darwin). Within a 12 month peak construction period, 850 truck movements would be required on public roads (assuming rail would be used to transport the majority of the rail line and sleepers). Detailed descriptions of expected transport requirements are presented in Chapter 13 and Appendix M of the Draft EIS.

The construction workforce is estimated to be an average of 150 direct jobs and up to 300 at peak times. The Proposal aims to employ up to 20% of staff from the local area and 25% from Alice Springs. The remaining workforce would be on a fly in / fly out (FIFO) arrangement. The construction workforce would be housed in a combination of temporary and permanent camp accommodation at the mine site and along the infrastructure corridor.

2.2.5 Operation

Mining is expected to be in half production from years one to five and in full production from years six to 25.

The mining method would be open-cut strip mining in defined pit areas using truck and shovel operations to remove overburden (waste rock) and to transport ore to the processing plant. Waste rock would be temporarily stored near the pits. Drilling and blasting is not proposed.

Processing of the mined ore is undertaken on-site in a beneficiation plant producing phosphate rock concentrate for load out. A surface TSF would be constructed to hold the first three years of tailings, after which time tailings would be placed in mined-out pits, capped with waste rock and progressively rehabilitated. The base of the surface TSF as well as the pits would not be lined. Tailings placed in the surface TSF would not be removed, but rehabilitated similarly to the mined-out pits.

Water for mining operations would be sourced from a borefield approximately 12 km south-west of the mine site. The Proponent estimates the water requirements to be

3.6 GL/y at full production. The borefield would access the Georgina Basin carbonate aquifer and is outside of a Water Control District.

The bore field comprises one existing and two new high-flowing water bores equally spaced over a distance of 1.5 – 2 km. The main water requirements would be:

- a) treated water for the processing plant, power station and wash down requirements
- b) potable water for domestic use and safety showers
- c) raw water for dust suppression and primary ore processing.

The water balance model (Supplement, Appendix 4) indicates all water extracted from the bore field will be treated on-site. Chemicals used in water treatment include sodium hypochlorite, ferric chloride (coagulant), polymer (flocculant), sodium metabisulphite, Hydrex 4104 (scale inhibitor), sodium chloride, and caustic.

An on-site gas power plant with a 24 MW capacity would supply an average load of approximately 16 MW at full mining production. Approximately 3.2 PJ/y of gas would be sourced from the Amadeus gas pipeline. Dual fuel capacity with an option to use diesel as a backup and solar power would be incorporated into the configuration. Transporting gas (either LNG or CNG) to site by road or rail is proposed as an option, particularly at the 1 Mtpa production rate.

At the beneficiation plant, the ore would undergo a process of wet screening, scrubbing, grinding, classification, flotation, thickening, filtration and drying. Chemicals used in the flotation circuit would include fatty acid (collector), polyacrylamide (flocculant), sodium silicate (silicate depressant) and soda ash (pH regulator). The processing plant would be designed to operate continuously over a 25 year design life and with a closed water circuit.

Process water from the beneficiation plant would be collected in lined ponds before being reused in the plant. Water separating from tailings in mined-out pits or in the surface TSF will be pumped to lined ponds and reused in the beneficiation plant, with a small fraction used for dust suppression.

Transport of ore is proposed by rail via the proposed 105 km rail spur connected to the Adelaide-Darwin rail to Port of Darwin. Train movements are anticipated to be 120 per year for years 1 to 5, and 240 per year for years 6 to 25.

Ship movements from Port of Darwin to international market are anticipated to be 20 per year for years 1 to 5, and 40 per year for years 6 to 25.

The Proposal would provide approximately 165 jobs at full operation and approximately 80 jobs during the first 3-5 years. The Proposal aims to employ up to 20% of staff from the area and 25% from Alice Springs. The workforce would be on a fly in / fly out (FIFO) arrangement and would be accommodated in a camp north of the mine site.

2.2.6 Closure

One of the objectives of mine closure is to reinstate natural habitat compatible with pastoral use (should this be the agreed post-mining land use). At closure, all mine site infrastructure and equipment would be removed and the site rehabilitated. Rehabilitation would be progressive, with mined-out pits being backfilled with tailings and waste rock. After tailings have settled, the surface TSF would be capped with a 1 m thick layer of waste rock. All areas, including backfilled pits and surface TSF, would be covered with at least 100 mm stockpiled soil and revegetated with local seeds. The final landform over the rehabilitated (backfilled) pits and surface TSF would consist of low convex shaped domed structures of about 1-2 m height with radial surface drainage.

The proposed Murray Downs Road realignment would be permanent and other infrastructure such as bores, the infrastructure corridor and access tracks may be left intact following consultation with landowners.

An updated Closure Report was included in the Supplement (Appendix 1). A detailed Rehabilitation Plan, including completion criteria and monitoring programs, would be developed to be incorporated into a Mine Closure Plan (MCP). Once prepared, the MCP would be regularly revised and updated as part of the Mining Management Plan (MMP) during the planning, construction and operation of the Proposal.

3 Consultation

The Draft EIS for the Proposal was on public exhibition for six weeks between 28 October and 8 December 2017. A total of 12 submissions were received. These included submissions from 10 NTG advisory agencies and two public submissions. All submissions were forwarded to the Proponent.

In preparing this Report, the NT EPA has considered each submission in relation to the Proposal's potential environmental impacts and risks.

3.1 Consultation with government agencies

The Proponent consulted with government agencies during the preparation of the Supplement. The issues raised and Proponent's responses are detailed in the Supplement and made available to the public on the NT EPA's website.

3.2 Public submissions

Public submissions were received from the Central Land Council (CLC) and the Arid Lands Environment Centre (ALEC).

The key issues raised by the CLC relate to:

- establishing a comprehensive Native Title Agreement
- ensuring appropriate sacred sites clearances
- ensuring communities benefit from the project (e.g. employment opportunities)
- ensuring appropriate consultation, with particular regard to access, archaeological sites and sacred sites
- concern about potential impacts to potable water supplies, both from drawdown and contamination, and ensuring appropriate monitoring
- concern about potential impacts to significant fauna, and ensuring appropriate monitoring
- concern about potential radiological impacts
- road safety, dust and deterioration of the roads due to increased traffic by heavy vehicles.

The key issues raised by Arid Land Environment Centre relate to:

- groundwater monitoring for potential adverse effects on the quality of domestic and stock bores
- chemical composition and volumes of tailings
- protection for migratory birds, including measures to cover wastewater and to line tailings dams

- 50% of the mine's energy demand should be sourced from renewable sources
- the land should be rehabilitated to a condition that enhances and restores environmental values instead of returning the land to a degraded pre-mining state.

The Proponent provided responses to the issues raised in the public submissions in the Supplement. The responses clarified the Proponent's intention to engage with traditional title holders and provided additional technical information to respond to concerns about potential impacts to groundwater and biodiversity; and additional clarity around operational matters and rehabilitation. This information was made available to the public on the NT EPA's website.

The NT EPA notes the Proponent has engaged with the CLC over a number of years, and acknowledges that the Proponent proposes a program of future engagement with relevant stakeholders. The NT EPA considers that consultation by the Proponent has been appropriate for the purposes of the EIA, which occurs early in the development of Proposals. The NT EPA makes recommendations for appropriate ongoing engagement with traditional title holders in Section 6.2.

The NT EPA has considered relevant environmental issues raised by the community and stakeholders in making this Report.

4 Key environmental factors

Having regard to the Notice of Intent, the EIS and comments from the public and advisory bodies during the EIS review, the NT EPA assessed the Proposal for its potential impacts on the NT EPA's factors (NT EPA, 2018). The NT EPA identified the following key environmental factors that may be significantly impacted by the Proposal:

- Hydrological processes
- Inland water environmental quality.

The NT EPA has considered the importance of other environmental factors during the course of its assessment. Those factors that were not identified as key environmental factors or that were addressed through consideration of the above factors are summarised at Appendix 2 of this Report. The key environmental factors are assessed in Section 4 of this report. The description of each factor shows why it is relevant and how it would be affected by the Proposal. The assessment of each environmental factor concludes with a judgement by the NT EPA about whether or not the Proposal can meet the NT EPA's environmental objective for each factor, with implementation of recommended management measures where required.

5 Assessment of environmental factors

This section evaluates the Proposal and presents the views of the NT EPA on the environmental acceptability of the Proposal. The environmental acceptability of this Proposal was considered with regard to the principles of Ecologically Sustainably Development (ESD), through analysis of:

- the Proposal (particularly which components or activities are likely to significantly impact the environment)
- the existing environment (particularly environmental values and sensitivities)
- the potential environmental impacts and risks of the Proposal and the evaluation of the significance of those impacts and risks

- the proposed avoidance or minimisation / mitigation measures to reduce potential impacts and risks to acceptable levels and to meet NT EPA objectives.

Conclusions drawn and recommendations made in this Report are drawn from consultation on the EIS with advisory bodies, the NT EPA's examination of the EIS and responses from the Proponent to comments and consultation. Recommendations are also made in this Report to add, emphasise or clarify any commitments made by the Proponent, where the avoidance or minimisation/mitigation measures proposed in the EIS are considered insufficient or where a safeguard is deemed particularly important.

In this Report, the recommendations (in **bold**) are preceded by text that identifies issues and undertakings associated with the Proposal. For this reason, the recommendations should not be considered or read in isolation.

The NT EPA acknowledges that detailed design and operational plans for the Proposal have not been finalised. Minor and insubstantial changes are expected in the design and specifications of the Proposal following the conclusion of the EIA process. It is necessary for approval mechanisms to accommodate subsequent changes to the environmental safeguards described in the final EIS and recommendations in this Report.

If the Proponent is able to demonstrate that any changes are unlikely to significantly increase potential impacts on the environment, then an adequate level of environmental protection could be achieved by modifying the conditions through relevant statutory approvals governing the Proposal. Otherwise, further environmental assessment may be required.

Recommendation 1

That the Proponent ensures that the Ammaroo Phosphate Project is implemented in accordance with all environmental commitments and safeguards:

- **identified in the final Environmental Impact Statement for the Ammaroo Phosphate Project (draft Environmental Impact Statement and Supplement to the draft Environmental Impact Statement)**
- **recommended in this Assessment Report 87**
- **to the satisfaction of the relevant regulator.**

The Northern Territory Environment Protection Authority considers that all safeguards and mitigation measures outlined in the Environmental Impact Statement are binding commitments made by the Proponent.

Recommendation 2

That the Proponent provides written notice to the Northern Territory Environment Protection Authority and the Responsible Minister if it alters the Ammaroo Phosphate Project and/or commitments, safeguards or mitigation measures in the Environmental Impact Statement in such a manner that the environmental significance of the action may have changed, in accordance with clause 14A of the Environmental Assessment Administrative Procedures.

The remainder of this section identifies and discusses the key environmental factors and potential impacts and risks to associated environmental values based on likely significance, the Proponent's investigations and studies, and commitments to identify, avoid, mitigate, monitor and manage the potential impacts and risks.

For each key environmental factor, the NT EPA assesses whether or not the proposal is likely to meet the environmental objective set for each factor. In defining its environmental objectives, the NT EPA also had regard to the principles of ESD

articulated in the Intergovernmental Agreement on the Environment (Australian Government, 1992):

- the precautionary principle
- the principle of intergenerational equity
- conservation of biological diversity and ecological integrity
- improved valuation, pricing and incentive mechanisms such as the “polluter pays” principle.

The NT EPA has summarised its consideration of ESD in Appendix 3.

5.1 Hydrological processes

5.1.1 Environmental objective

Maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

5.1.2 Environmental values

5.1.2.1 Groundwater hydrology

The Proposal is located in a hot, arid climate characterised by low rainfall and high evaporation. In an environment with scarce water resources, the efficient use of water and protection of groundwater resources is of high importance.

The mine will source its water supply from the nearby Georgina Basin carbonate aquifer, with the bore field being located approximately 21 km west of the boundary of the Western Davenport Water Control District. The Georgina Basin carbonate aquifer is unconfined, connected to the broader Georgina Basin to the east and infilling the Wiso Basin to the west. The Georgina Basin is the most extensive groundwater aquifer in the region, underlying approximately one quarter of the NT and extending into south-west Queensland. Reported groundwater recharge estimates for the region range from 0.2 mm to 5-12 mm per year. The carbonate aquifer has value as a water source for human and stock consumption. Current users are pastoralists (the nearest stock bore is 15 km and the nearest pastoral station is 30 km from the bore field), and communities (the nearest bores for Ampilwatja are 22 km from the bore field).

Groundwater in aquifers may have value for groundwater dependent ecosystems including vegetation and subterranean fauna.

The EIS stated that groundwater underneath and adjacent to the mine site is in a fractured rock aquifer located in the low-yielding Proterozoic basement aquifer approximately 60 to 80 m below the proposed mine site. Recent information provided by the Proponent indicated that there is no aquifer below the mine, stating that no groundwater was intersected by 3700 drill holes used for the identification of the phosphate resource, and four deep (approximately 100 m) bore holes searching for groundwater on the mineral leases. The Proponent stated 11 bores encountered igneous basement rocks, which have a very low potential for groundwater to occur underneath them.

5.1.2.2 Surface water hydrology

Surface water features in the region are ephemeral, supporting flora and fauna and recharging groundwater resources across the region.

The Proposal is located in the Diamantina-Georgina Rivers Basin, with Taylor Creek being the closest watercourse to the Proposal. Three tributaries of the creek's drainage system intersect the western end of the proposed infrastructure corridor. Several

ephemeral swamps are scattered in the vicinity of the central section of the infrastructure corridor. While the corridor alignment avoids the individual swamps, it crosses a linkage between two swamps.

While the proposed mine site does not have any surface water features, one drainage floor exists to the north-east and is currently dammed for pastoral purposes.

5.1.3 Potential impacts

5.1.3.1 Groundwater hydrology

The Proposal may impact on environmental values that depend on the existing hydrological groundwater regime through:

- a) long term groundwater abstraction from the nearby Georgina Basin aquifer, potentially leading to groundwater drawdown, which may
 - contribute to a reduction in the volume of groundwater available to current and future users of regional aquifers; and
 - impact significant groundwater dependent ecosystems, such as subterranean fauna and groundwater dependent vegetation communities
- b) seepage from mining activities, potentially increasing the water table of the basement aquifer underneath the mine site.

5.1.3.2 Surface water hydrology

The Proposal has the potential to impact on ephemeral swamps and drainage floors along the infrastructure corridor by altering runoff pathways and flood regimes, and increasing sedimentation as a result of erosion.

Potential impacts on water quality are discussed in section 5.2 under inland water environmental quality.

5.1.4 NT EPA assessment

5.1.4.1 Groundwater hydrology

Groundwater drawdown

The proposed volume of water abstraction is substantial. By way of comparison, the Proposal would abstract more than a third of the water abstracted annually to supply reticulated water to the town of Alice Springs, making the Proposal the second largest groundwater user in the region.

An estimated 3.6 GL/y of groundwater will be extracted from the nearby Georgina Basin carbonate aquifer. At that rate, the Proponent's modelling predicts drawdown (by year 25 of mining) of up to 3.7 m at the closest pastoral stock bore, up to 2.7 m at the closest community water supply bore and up to 0.5 m within a 25 km radius. The Proposal concluded the predicted drawdown would not affect water availability due to the extent and substantial vertical extent of the aquifer (at least 185 m at the bore field and 283 m at a bore 15 km south-east of the bore field).

Drawdown from construction bores is expected to be negligible due to the low extraction rate and short duration.

While the potential for the Georgina Basin aquifers to yield the required amounts is recognised as feasible, the proposed groundwater operation is largely based on limited local and inferred data. The potential for production bores to produce the required amount is not yet demonstrated. The Proponent has recognised the risk that bores may not yield the design capacity and proposed to install additional bores, if necessary, to

meet the proposed mine's water requirements. The NT EPA recommends to that monitoring of baseline water hydrology commence as soon as feasible to provide greater certainty of water yields.

The Proponent has committed to a zero reduction in water availability due to mining to other users. The Proponent presented a Water Management Plan (WMP), which included a program to monitor groundwater levels at a network of observation bores, and monitor the volume of groundwater extracted from the bore field. The Proponent committed to seek endorsement for the WMP from the relevant regulator prior to implementation.

The Proponent proposes the following mitigation measures to be implemented if drawdown exceeds the model prediction:

- re-assessment of predicted drawdown at receptors
- make-good measures at receptors to ensure water availability, e.g. deepening of bores and/or upgrading of pumps
- investigation and implementation of increased water efficiencies
- modification of pumping regimes.

An independent peer review (Supplement, Appendix 7) endorsed the groundwater monitoring program with the following improvements:

- identify the target aquifers/formations at each of the proposed monitoring locations
- identify that water level observations from proposed bores > 30 km from the site would be used to identify natural recharge
- define water level monitoring methods and measurement interval for each monitoring bore
- water levels should be logged daily and supported by quarterly manual readings and downloads
- estimate annual extraction rates of other users (e.g. pastoralists)
- survey all monitoring and production bores to a common height datum (MAHD) to ± 0.1 m vertical accuracy to allow for accurate characterisation of groundwater flow directions

The NT EPA supports these recommendations as they provide greater certainty to the identification of impacts on groundwater hydrology.

To ensure the predicted drawdown is appropriately managed, the NT EPA recommends the development of a Water Abstraction Management Plan (WAMP), separate to the Water Management Plan. The WAMP should focus on issues associated with the management of groundwater abstraction and the monitoring of groundwater hydrology. Complementary to the WAMP, the Water Management Plan should focus on all issues associated with water use on the project site, operational water management and water quality.

The NT EPA is of the opinion that there is limited accuracy in the quantitative predictions from preliminary modelling and considers continual model review based on real monitoring data to be the preferred option to assess potential impacts. The NT EPA considers it would be appropriate to update the model frequently to improve its predictive capacity and enable a better assessment of potential environmental impacts of water abstraction and subsequent drawdown. The NT EPA recommends model updates are incorporated into the WAMP to ensure monitoring results and model outputs for groundwater drawdown inform management responses for water abstraction.

Recommendation 3

That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Water Abstraction Management Plan to the relevant regulator prior to mining that:

- includes a framework identifying the location, timing, methods and parameters for the collection of further groundwater information
- incorporates the recommendations of the independent peer review to improve identification of natural recharge processes and extraction rates of other users; characterisation of flow and flow directions; and robustness of the water level baseline by capturing seasonal changes
- incorporates a program to monitor groundwater levels at nearby stock and community bores
- incorporates a program to monitor drawdown impacts on the groundwater system within the adjacent Western Davenport Water Control District
- is based on robust groundwater level baseline data capturing seasonal changes over at least 12 months at all proposed groundwater abstraction monitoring bores, including borefield and nearby stock and community bores
- incorporates all relevant commitments made by the Proponent in the Environmental Impact Statement, including a zero reduction in water availability to other users from mining activities
- is developed in consultation with relevant stakeholders, including other groundwater users
- actively and continuously seeks to improve knowledge of aquifers and groundwater tables affected by the Proposal and incorporates these into the model
- is independently peer reviewed by a suitably qualified independent professional
- is developed and implemented to the satisfaction of the relevant regulator
- is to be updated at least annually
- reports all water monitoring data with an assessment of the impacts on groundwater hydrology in an annual Water Management Report.

Public disclosure of the annual Water Management Report and each updated Water Abstraction Management Plan should be provided on the websites of (as applicable) the Proponent, the Operator and relevant authorities.

Groundwater dependent vegetation

It is unlikely that groundwater dependent vegetation would be impacted by the Proposal. Groundwater in the vicinity of the Proposal is generally deeper than 20 m, which studies in the nearby Ti Tree and Western Davenport Water Control District identified as the critical maximum depth for groundwater dependent vegetation (Cook & Eamus, 2018).

Subterranean fauna – (stygo fauna)

Stygo fauna have been found in unconfined aquifers elsewhere in central Australia. Investigations have identified that the nearby Wiso Basin, which is connected to the Georgina Basin carbonate aquifer, has a high potential for stygo fauna (Moulds & Bannink 2012). It is therefore possible that stygo fauna could be present in the proposed bore field aquifer.

Based on current knowledge, there is low potential for an aquifer to be present beneath the mine site (fine grained unsaturated sedimentary rock). As a result, it is highly unlikely suitable habitat for stygo fauna will be present.

The Georgina Basin carbonate aquifer of the proposed bore field is more likely to meet suitable habitat requirements for stygo fauna as defined by Hose et al. (2015), who stated alluvial, karstic and some fractured rock aquifers are likely to host stygo fauna at depths of less than 100 m. If present, stygo fauna could be impacted by groundwater drawdown from the bore field in the Georgina Basin carbonate aquifer. The Proponent's modelling predicts drawdown of greater than 1 m to occur within approximately 22 km of the proposed bore field after 25 years of mining operations. This zone represents a very small proportion of the extensive Georgina Basin, in addition to which there is a low probability of endemic species being associated with this specific location, so the modelled drawdown is unlikely to result in a significant reduction of habitat for endemic stygo fauna species.

The NT EPA considers it is unlikely that the Proposal would lead to a significant impact on stygo fauna. However, verification of groundwater modelling should continue for the life of the mine and, if a significant deviation from modelling is detected, the potential impacts associated with the variance should be reconsidered and referred to the NT EPA where there is potential for a significant impact to the environment.

Water stewardship

The Proposal is located in an arid region where groundwater is a shared resource with high value. While the Georgina Basin is known to be a large groundwater resource, it is not part of a Water Control District. The aquifer storage, sustainable yield and consumptive pool have not been quantified. Mining within the region could affect water availability for other potential uses in the future. The NT EPA considers that the Proponent should minimise groundwater abstraction, maximise water re-use and demonstrate best practice in water stewardship as recommended by the International Council on Mining and Metals (ICMM, 2014). The ICMM water stewardship framework recommends effective management of water at operations, collaboration to achieve responsible and sustainable water use, and the application of strong and transparent corporate water governance.

Recommendation 4

That approvals and decisions for the Proposal have conditions that require the Proponent to:

- **allocate clear responsibilities and accountabilities for water use and management**
- **provide regular updates of the projected water balance for the Proposal in the Water Management Plan, including detailed estimates for the various phases of the Proposal and specifying the source and quantity of the water to be used**
- **demonstrate how water saving considerations are integrated in Proposal planning including final design and technologies**
- **report on continual improvement initiatives in water use efficiency including the provision of relevant water use targets**

- provide details on how water will be effectively managed during proposed operations, including minimising water consumption, maximising water reuse and minimising waste water
- abstract water from bores only when equipped with operating flow meters
- record the volume of water abstracted from the borefield and the corridor construction bores
- report water use performance in relation to targets, and any change to targets in an annual Water Management Report to stakeholders

Public disclosure of the Water Management Plan and annual Water Management Report should be provided on the websites of (as applicable), the Proponent and relevant regulatory authorities.

Rise in water table due to seepage

The Proponent's groundwater model predicts that seepage from the proposed 25 years of operations would result in a rise in the water table of 3.6 m to 25 m at the mine site. Proposed mitigation measures for water level rises beyond seasonal variation would be to pump and treat seepage from underneath the TSFs and implement underdrainage in subsequent in-pit storage cells to reduce seepage.

The NT EPA notes the seepage modelling was based on limited local bore data and uncertainty remains on the exact location, extent and characteristics of any aquifer underneath the proposed mine site such that the seepage modelling is considered uncertain. As outlined in section 5.1.2.1, recent information provided by the Proponent indicated that there is no aquifer below the mine site.

Nevertheless, the NT EPA recommends that the proposed tailings leachate seepage monitoring program should be implemented, with results used to improve the existing seepage model.

The proposed monitoring network consists of four bores downgradient and one bore up gradient of tailings storage facilities. An independent peer review (Supplement, Appendix 7) endorsed the mine site groundwater monitoring program for tailings leachate seepage with the following improvements:

- survey all monitoring and production bores to a common height datum (MAHD) to ± 0.1 m vertical accuracy to allow for accurate characterisation of groundwater flow directions
- once sufficient monitoring data has been obtained, assess adequacy of the location of each bore to meet its monitoring objective. If the stated objective is not met additional bores should be installed.
- relocate bore AMOBS09 to immediately adjacent to the downgradient side of the 0-2 year pit to monitor potential seepage from in-pit tailings in the early stage of mine development
- commence water level monitoring in AMOBS6 two years prior to mining to establish seasonal variation in groundwater levels

The NT EPA supports these recommendations as they provide greater certainty to the identification of seepage and impacts on groundwater hydrology, should groundwater be present at the mine site.

Recommendation 5

That approvals and decisions for the Proposal have conditions that require the Proponent to:

- **update the seepage monitoring program in the Water Management Plan to include recommendations of the independent peer review**
- **annually review and, if required, update the seepage model.**

Findings of the review and updates to the seepage model should be reported in the annual Water Management Report.

5.1.4.2 Surface water hydrology

The proposed infrastructure corridor would largely avoid surface water drainage systems, except that it would intercept tributaries to Taylor Creek's drainage system at its western end and intercept an ephemeral wetland corridor connecting two swamps in the central section. The construction and operation of the gas pipeline and railway line has the potential to impact on surface water hydrology of intersected drainage systems and their sensitive vegetation communities.

The railway line will be raised above the 25 year ARI flood level with sufficient crossing structures (e.g. culverts) to minimise changes to flood levels within the upslope and downslope environments. Each culvert will have downstream energy dissipation structures.

The proposed mine site will not intersect any surface water features. Flood protection berms will be installed to divert surface water flows away from the mine site. Potential impacts on the mine site with and without these berms were modelled for a 100 year ARI flood event. Based on assessment of the modelling outcomes, the flood protection berms would be installed along the eastern and western sides and partially along the north-eastern and south-eastern sides of the open pits. Infrastructure would be constructed above the 100 year ARI flood level.

The NT EPA supports the Proponent's commitment to implement erosion and sediment controls to minimise the erosion risk associated with the diversion of rain and flood water, and to maintain the integrity of the flood protection berm structures.

5.1.4.3 Summary and Conclusion

The NT EPA's assessment of the key environmental factor - Hydrological processes identified the following potential impacts and risks:

- The proposed water use is substantial
- The proposed groundwater extraction is predicted to cause a drawdown in the Georgina Basin carbonate aquifer that could reduce the availability of water to other users.

In addition to the proposed management, monitoring and mitigation measures, the NT EPA recommends:

- the implementation of continual improvements in water use and water efficiencies to minimise groundwater abstraction and impacts on water availability for other potential uses in the future
- the development of a Water Abstraction Management Plan (WAMP) with a focus on issues associated with the management of groundwater abstraction and the monitoring of groundwater hydrology

- the development of a Water Management Plan (WMP) with a focus on all other issues associated with water use, operational water management and water quality
- the incorporation of all recommendations from the independent peer review and commitments made by the Proponent into the WAMP
- the monitoring of groundwater levels at nearby stock and community bores
- the establishment of hydrological baseline data at all groundwater abstraction monitoring bores
- further transparency for groundwater abstraction, including:
 - o consultation with stakeholders on the Proponent's use of groundwater
 - o demonstration of best practice water management in line with the International Council on Mining and Metals water stewardship framework (ICMM 2014)
 - o public accountability through public disclosure of the WAMP, the WMP and annual Water Management Reports.

With the implementation of the relevant management plans and recommendations identified above, the NT EPA considers that the Proposal could be conducted in such a manner that its objective for hydrological processes is likely to be met.

5.2 Inland water environmental quality

5.2.1 Environmental objective

Maintain the quality of groundwater and surface water so that environmental values including ecological health, land uses, and the welfare and amenity of people are protected.

5.2.2 Environmental values

5.2.2.1 Groundwater quality

Groundwater quality at the proposed bore field (Georgina Basin carbonate aquifer) is considered to be marginal for human consumption due to elevated salinity, but is suitable for pastoral use. The chemical composition is strongly influenced by the carbonate rocks of the aquifer.

When present, groundwater quality at the mine site is not potable due to elevated fluoride, nitrate and boron, but is suitable for pastoral use (Draft EIS, Appendix H).

5.2.2.2 Surface water quality

Little information is available on surface water quality due to the lack of permanent surface water in the area and the low frequency of flows in local watercourses. Some local data and data for surrounding catchments indicate generally good water quality (when present) with neutral pH and low salinity (NTG 2018).

5.2.3 Potential impacts

5.2.3.1 Groundwater quality

Construction, operation and closure of the Proposal have the potential to result in direct impacts on groundwater quality from the following sources:

- acid and metalliferous drainage (AMD) and saline drainage from mined materials

- infiltration or leachate of naturally occurring radioactive materials
- infiltration or leachate from tailings facilities
- infiltration or leachate from waste rock dumps.

5.2.3.2 Surface water quality

Construction, operation and closure of the Proposal have the potential to result in the direct impacts on surface water quality from the following sources:

- uncontrolled discharge of process water
- mobilisation of soils/sediment during clearing, mining and closure activities, and from post-closure landforms
- lateral, above-ground seepage from the surface TSF
- recycled process water being used for dust suppression
- surface runoff within the mine site, including runoff from ore and phosphate rock concentrate stockpiles
- fuel and chemical spills.

Contamination of surface water also has the potential to impact groundwater quality indirectly through infiltration to groundwater aquifers.

5.2.4 NT EPA assessment

5.2.4.1 Groundwater quality

Potential acid and metalliferous drainage (AMD) and saline drainage from mined materials

The risk of acid and metalliferous drainage (AMD) and saline drainage from waste rock and tailings was assessed through geochemical analysis (Draft EIS, Appendix I, AMD Assessment and Management Report and Supplement, Appendices 8 to 11) and the initial three months of a long-term leachate study (Supplement, Appendix 12, Barrel Leach Results).

Analysis of 202 waste rock samples (proportionally representing the lithological units to be mined) and two synthetic tailings samples included chemical assays, static AMD tests, leach tests (using the Australian Standard Leaching Procedure (ASLP)), salinity tests and soil stability assessments. In addition, a field barrel leach test (kinetic test) investigated the AMD risk associated with the long-term effects of monthly rain percolating through stockpiles of three common overburden (waste rock) materials, ore and top soil. All five samples were also investigated for the mobilisation of soluble chemicals using ASLP.

The chemical assay showed that the waste rock is low in sulfur, potentially toxic metals and radioactive elements relative to global crustal shale averages. Static net acid generation (NAG) testing indicated that all of the tested material is non-reactive and non-acid-forming (NAF). The NAF classification was also supported by the low total metal and sulfide content, neutral NAG, positive net acid production potential (NAPP), and high neutralisation potential ratio (NPR). The results were consistent with a high level of oxidation and weathering typically found in material above the long-term water table.

ASLP and initial field barrel leach testing indicated waste rock may produce leachate with elevated metals, primarily zinc, relative to 95% aquatic ecosystem or drinking water guidelines. Leachate from the field barrel testing was within levels suitable for livestock and irrigation. Salinity levels were classified as very low to medium (DME QLD, 1995) with high sodium adsorption ratios (SAR) in some ASLP leachates, but not in the field

barrel leachates, indicating that ASLP leach testing may overestimate likely concentrations. Should high SAR be encountered, mitigation options include using a clayey soil amendment with crushed limestone or gypsum to raise soluble calcium concentrations.

The two synthesised tailings samples contained total and leachable element analyte concentrations similar to the waste rock.

The initial geochemical assessment of the waste rock indicates that the salinity and AMD risk would be very low and the material could be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste.

The initial results indicate that leachate from excavated waste rock would be unlikely to present a risk to nearby receptors provided leachate or runoff does not enter surface water bodies undiluted. The results further indicate that waste rock would be suitable for management in unlined waste rock dumps with appropriate monitoring of metals and metalloids in potential receptors, such as groundwater and surface water.

The Proponent committed to implement a peer-reviewed and regulator-endorsed Water Management Plan, which would include monitoring of changes in groundwater and surface water quality.

Although the proponent considered the AMD risk as low, as a precautionary measure, the proposed AMD Management Plan (Draft EIS, Appendix I) presents a testing and monitoring regime consistent with that required for materials of high AMD risk. Monitoring would focus on in-situ material scheduled for mining, constructed landforms (waste rock dumps, ROM pad and mineralised waste stockpiles inside or outside of pits) and water (surface and groundwater).

Based on the outcomes of the initial geochemical assessment and the conservative approach of the AMD Management Plan, the Proponent's AMD risk assessment (Draft EIS, Appendix I) concluded that the risk is likely to be low. The Proponent committed to undertake additional testing in the pre-production phase for suitable capping/encapsulation material, additional NAG and NAPP testing, and additional tailings sampling, in order to increase certainty in the geochemical characteristics of the mined materials.

An independent peer review (Supplement, Appendix 3) endorsed the general findings of the AMD Assessment and Management Report (Draft EIS, Appendix I). The review supported the Proponent's commitment to additional tailings testing and recommended the inclusion of ore in future geochemical testing. The NT EPA supports these recommendations.

As a precautionary approach and to minimise the risk associated with unlined permanent tailings storage facilities, the NT EPA also recommends the Proponent conduct aggressive tailings leach testing prior to mining. In addition, The NT EPA recommends the Proponent extract and analyse actual tailings seepage and decant water during the first 12 months of operation. The results will inform any requirement for mitigation options such as lining and tailings treatment. If tailings seepage exceeds the agreed threshold levels then mitigation options such as lining of the tailings storage or additional tailings treatment must be implemented immediately. If the exceedance changes the environmental significance of the Proposal, the altered Proposal should be referred to the NT EPA in accordance with Recommendation 2.

Recommendation 6

That approvals and decisions for the Proposal have conditions that require the Proponent to provide an updated Acid and Metalliferous Drainage Management Plan to the relevant regulator prior to mining that:

- incorporates the recommendations of the independent peer review and all commitments made by the Proponent in the Environmental Impact Statement including further testing in the pre-production phase (geochemical testing of tailings and ore, identification of suitable capping/encapsulation material and additional NAG and NAPP testing)
- includes aggressive leach testing of tailings prior to mining with the results to be reported to the relevant regulator for assessment and, if required, identification of appropriate mitigation measures.
- incorporates a program to analyse in-situ extracts of tailings seepage and decant water during the first 12 months of operation with the results to be reported to the relevant regulator for assessment and, if the seepage composition exceeds the agreed threshold levels, then mitigation options such as lining the tailings storage or additional tailings treatment must be implemented immediately
- includes a program for regular geochemical testing of all materials scheduled for mining or in constructed landforms (including ore stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested
- includes a contingency plan outlining trigger levels for actions, specific responses and mitigation measures, and consequences for operational, rehabilitation and closure activities.

The Acid and Metalliferous Drainage Management Plan should be developed and implemented to the satisfaction of the relevant regulator.

Naturally occurring radioactive materials

ASLP leachate tests of the waste rock indicated a low radiation risk with maximum concentrations of uranium (44.9 ppm) and thorium (30.2 ppm) below the threshold concentrations for naturally occurring radioactive materials (NORM) of 80 ppm and 246 ppm respectively, which are equivalent to the specific activity of 1 Bq/g (DME, 2008; DNRM QLD, 2014; IAEA, 2004). Uranium concentrations of one historical tailings sample (16 ppm) and three export phosphate rock concentrate samples (maximum 22 ppm) were also below the NORM threshold. A conservative estimate of exposure through dust inhalation was less than 0.1 mSv/y and occupational doses (above natural background) were calculated to be less than the national standard public dose limit of 1mSv per year (NDRP, 2017) (Draft EIS, Appendix K).

Based on the initial sampling, the radiological impact assessment of the Draft EIS (Appendix K) concluded potential radiation exposure is very low and no special radiation protection controls are required. Further, the Ammaroo ore is not radioactive and therefore not subject to regulatory control in accordance with the criteria for radioactive material (IAEA, 2004). The assessment indicated general health and safety requirements (such as dust controls) will be adequate for ensuring that potential workers doses remain negligible.

In order to verify the initial radiation exposure estimates, the Proponent committed to establish a passive gamma, radon and thorium monitoring network (Draft EIS; Supplement). The location of these environmental monitoring sites will be identified in consultation with the relevant regulator. Radon and gamma baseline data would be collected for at least one year prior to the start of operations.

The NT EPA supports the Proponent's commitment to a monitoring program to measure actual radiological exposure. In addition, the NT EPA has recommended that regular radiological testing of potential sources be undertaken.

Recommendation 7

That the Acid and Metalliferous Drainage Management Plan, referenced at Recommendation 6, include a program for regular radiological testing of all materials scheduled for mining or in constructed landforms (including ore stockpiles and tailings), including the frequency of monitoring, methods to be used, and number of samples to be tested.

Infiltration or leachate from tailings facilities

Since tailings would be permanently stored in unlined facilities, the chemistry of the tailings at the source and pathways of the tailings and tailings leachates need to be fully understood to enable effective management of any potentially significant, short- or long-term impacts to environmental values, including ecological health, land uses and human health welfare and amenity.

The chemistry of tailings and tailings leachate was investigated as part of the AMD risk analysis (Draft EIS, Appendix I) for one synthetic tailings sample (see above). Additional testing of a second synthetic tailings sample comprised geochemical analysis of acid rock drainage and contaminant mobility potential (Supplement, Appendix 8); analysis of likely tailings decant water for a range of metals and metalloids (Supplement, Appendix 9); and metallurgical testing of the tailings solids (Supplement, Appendix 10).

Analysis of the two synthesised tailings samples indicated total and leachable element analyte concentrations similar to waste rock, comprised primarily of silicates with minor to moderate amounts of calcium, aluminium, phosphorous and iron. The tailings were not potentially acid-generating due to a lack of acid-generating sulfur and an excess of acid neutralising capacity.

Results of both samples were compared to Australian Drinking Water Guidelines (ADWG) (NHMRC, NRMCC, 2011) for aesthetic and health-based guideline values; the ANZECC & ARMCANZ 2000 guidelines for long-term irrigation, livestock drinking water, and the protection of slightly to moderately disturbed freshwater aquatic ecosystems at the 95% of species level; and average Ammaroo groundwater concentrations (Supplement, Appendix 9).

The tailings leachate and decant analyses were generally within drinking water guidelines, except for arsenic, lead and nickel, which exceeded the guidelines by a factor of less than two. Fluoride exceeded the drinking water guidelines in the first three leaching cycles but was below guidelines in the following cycles, indicating it would be removed in initial flushes.

Compared to the ANZECC & ARMCANZ 2000 irrigation guidelines, tailings leachate and decant showed slightly alkaline pH and slightly elevated SAR, fluoride, phosphorous and molybdenum, which may increase soil dispersion and impact crop yield and nutrient load when used in an agricultural setting. If used for dust suppression, tailings leachate and decant water do not present a significant risk to the environment unless used on a large scale adjacent to waterways.

With the exception of pH and fluoride, all samples were within drinking water guidelines for sensitive livestock. Similarly to ADWG, only the first flush exceeded fluoride levels.

The 95% freshwater aquatic ecosystem guideline values (FAE95%) were exceeded for several metals and nutrients with aluminium, copper and phosphorus exceeding the guideline by more than a factor of 10. If a direct discharge of high volumes of leachate occurred, the elevated phosphorous may present a risk to surface water, but is unlikely to present a risk to groundwater as it is readily adsorbed in the soil column.

Analysis results indicated that the synthesised tailings sample had a low AMD and toxicity risk, with some slightly elevated metals and fluoride but low salinity. Uranium

concentrations were below the NORM threshold. Based on tailings particle size distribution and hydraulic conductivity of the fractured rock aquifer, it was estimated that tailings seepage could cause a rise in the water table beneath the mine site (see section 4.2). The Proponent's modelling indicated that the seepage plume would move 400 m downgradient in 100 years and would be diluted to a 10% fraction of leachate in 90% groundwater (Supplement). There are currently no receptors within this distance and preliminary characterisation of tailings seepage indicates that beneficial use of the water would be unchanged. As discussed in section 5.1.3 recent information provided by the Proponent indicated that there is no aquifer below the mine site.

The proponent committed to additional tailings testing pre-production, including bulk leach testing. The NT EPA notes that all testing prior to mining would be undertaken on synthetic tailings. The NT EPA considers it necessary there be ongoing regular testing of tailings during operations, and has specified in Recommendation 6 that tailings be included in a program of regular geochemical testing.

The NT EPA's preferred approach is to avoid or mitigate contamination at the source rather than to manage resultant significant environmental impacts. The ongoing characterisation and monitoring of potential contamination sources are addressed in Recommendation 6. In addition, the NT EPA has recommended the identification of potential 'indicator' contaminants and concentrations in waste rock and tailings leachates that could be used as trigger thresholds for management and mitigation actions. Due to the large volumes of water being treated, the NT EPA has recommended an assessment of chemicals added for water treatment and beneficiation, especially flocculants, be undertaken and reported in the Water Management Plan. The Proponent committed to use the non-toxic anionic form of polyacrylamides. The type of polyacrylamide and polymer flocculants should be clearly identified and polyacrylamides with more than 0.05% of the neuro-toxin acrylamide monomer should be avoided (Sojka & Surapaneni, 2000). The assessment should consider the potential of these chemicals and their breakdown products to contaminate receiving environments.

The Proponent committed to construct the surface TSF to Australian National Committee on Large Dams Inc. guidelines (ANCOLD, 2012) and that an independent and appropriately qualified Certified Engineer would oversee the design, construction, operation, rehabilitation and closure of the surface TSF. The NT EPA supports this approach.

At closure, surface tailings would remain within the unlined surface TSF. The final landform of the rehabilitated surface TSF and the infilled pits would allow infiltration of rainwater to occur.

The following preventative measures are proposed by the Proponent to reduce the quantity of water, especially poor quality water, infiltrating the groundwater:

- a) The proposed mining, processing and rehabilitation operations are designed to recycle all process water and tailings decant water by storing it in lined ponds for reuse in the processing plant.
- b) Water recovery from, and hence dewatering of, the tailings (40 – 50 % water content) would be facilitated by the design of the tailings storages encouraging accumulation and extraction of decant water. Geotechnical testing (Supplement) indicated that most of the settlement occurs within the first 24 hours, reaching approximately 0.9 t/m³ dry density, with 30% of the total tailings water being discharged.
- c) Exposure to high evaporation rates in the arid environment would further reduce moisture in the tailings.

The Proponent has stated that emergency measures, such as pumping of excess water into pits, would be in place to avoid uncontrolled surface discharge to the surrounding environment.

Infiltration and leachate from tailings will be monitored through a groundwater monitoring program, which would be part of a peer-reviewed and regulator-endorsed Water Management Plan. Four of the 18 monitoring bores will be placed downgradient of the surface TSF and in-pit tailings storages to target tailings seepage. They will be monitored quarterly for water quality and logged daily for water levels. In order to ensure the monitoring program is appropriate and scientifically robust, NT EPA recommends an independent external audit of the seepage monitoring program should be undertaken after four and ten years of tailings deposition and the auditor report to the relevant regulator. The NT EPA recommends the monitoring data and audit report should be made publicly available through an annual Water Monitoring Report.

The Proponent proposes to establish a water quality baseline, if groundwater is present, over at least 12 months prior to mining and has also proposed that any exceedance of this baseline will trigger mitigation measures such as extracting existing seepage and reducing seepage from subsequent in-pit storage through underdrainage.

Should no groundwater be present, the NT EPA has recommended the use of livestock drinking water guidelines (ANZECC & ARMCANZ, 2000) as pastoralists are beneficial users of the downstream aquifer that may be impacted by the modelled plume. Initial tailings leachate and decant water analysis were within these guidelines, with the exception of a slightly elevated pH and fluoride (during the initial flush).

The significance of exceedances should be assessed by the relevant regulator. Measures to mitigate the source of contamination may include treatment of tailings and/or lining of tailings storage facilities and should be implemented immediately. Exceedances that change the environmental significance of the Proposal must be referred to the NT EPA in accordance with Recommendation 2.

Recommendation 8

That approvals and decisions for the Proposal have conditions that require the Proponent to develop a Water Management Plan to the satisfaction of the relevant regulator prior to mining. The plan should include:

- **an assessment of chemicals added during water treatment and the beneficiation process, including an assessment of their behaviour and breakdown products in tailings and tailings decant/seepage and potential to contaminate the environment. In particular:**
 - **clearly identifying the type of polyacrylamide and polymer flocculants**
 - **polyacrylamides with more than 0.05% of the neuro-toxin acrylamide monomer are not to be used**
- **recommendations of the independent peer review to monitor seepage during the early stages of mine development**
- **robust pre-mining groundwater quality baselines to be used as trigger levels for mitigation measures, or should no groundwater be present, livestock drinking water guidelines to be used as trigger thresholds**
- **in line with the program to monitor potential contamination sources (Recommendation 6) potential contaminant concentrations in waste rock and tailings leachate should be identified and used as trigger thresholds for management actions to mitigate the source of contamination**
- **contingency measures to mitigate the source of contamination, if trigger values are exceeded**

- a robust groundwater quality monitoring program that can quantify the extent and quality of any potential seepage from the proposed mine site
- a requirement for an independent external audit of the groundwater quality monitoring program by a suitably qualified and experienced professional after four and ten years of tailings deposition. The auditor is to report to the relevant regulator.

All water quality monitoring data, trigger values, audit reports and an assessment of any impacts should be made publicly available in an annual Water Management Report on the websites of (as applicable) the Proponent, the Operator and relevant regulatory authorities.

Infiltration or leachate from waste rock dumps

The Proposal outlines that waste rock would be stored in unlined stockpiles in various locations around the mine site until required for progressive rehabilitation. Infiltration of run-off would mainly occur after rain.

The geochemical assessment of the waste rock indicates that the risk of AMD would be low and the material could be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. Although phosphorous was highly elevated in the waste rock, it was not elevated in the ASLP waste rock leachate, which is consistent with the low solubility of phosphate minerals.

The results indicate that waste rock would be suitable for management in unlined waste rock dumps with appropriate monitoring of metals and metalloids in potential receptors, such as groundwater (as per Recommendation 8) and surface water.

5.2.4.2 Surface water quality

The NT EPA accepts the difficulty of establishing a robust baseline for surface water quality conditions due to the ephemeral flows present in the region. Surface water quality is also likely to vary over the course of flow or flood events. This makes assessment of likely or actual impacts difficult and the implementation of reactive management measures more problematic. In the view of the NT EPA, this reinforces the importance of preventative measures.

Uncontrolled discharge of process water

An uncontrolled discharge, whether unplanned (e.g. due to structural failure) or caused by rain and flooding, was identified as the primary pathway for potential contamination of surrounding surface waters. In the EIS, the Proponent assessed the residual significant impact would be low due to:

- the absence of surface waters, including ephemeral drainages, in the immediate vicinity and downgradient of the proposed mine site
- the implementation of preventative measures such as a nil-discharge mine site design, process water ponds with a 100 year ARI freeboard capacity, flood protection berms, emergency procedures and ANCOLD construction standards for the surface TSF
- the implementation of audited erosion and sediment controls (IECA, 2008), including an ESCP, to maintain the integrity of the infrastructure, such as surface TSF and flood protection berms
- the implementation of a Hazardous Substances Management Plan and an Emergency Response Management Plan for the prevention and mitigation of accidental spills of hazardous materials

- the implementation of a water quality monitoring program for ephemeral surface waters in the region
- the adoption of appropriate trigger values for mitigation options. The 95% freshwater aquatic ecosystems species survival trigger values (ANZECC & ARMCANZ, 2000) would be used until site specific trigger values, based on at least 30 months baseline data, are developed.

The NT EPA supports these measures.

Mobilisation of soils/sediment during clearing, mining and closure activities, and from post-closure landforms

The Proponent has committed to implement best-practice erosion and sediment controls (IECA, 2008), including an erosion and sediment control plan ESCP developed by a Certified Professional in Erosion and Sediment Control and approved by the regulator, for all aspects and stages of the mine's operation and closure. These would form part of the MMP and implementation of the ESCP will be regularly monitored by a suitably qualified third party auditor, to the satisfaction of the relevant regulator. Post-closure monitoring will include assessment of the physical and geotechnical stability of post-closure landforms and the success of rehabilitation and revegetation.

The construction of the gas pipeline and railway line has the potential to impact on intersected drainage systems and their sensitive vegetation communities through sedimentation.

In order to maintain surface water quality the NT EPA recommends all sections of the infrastructure corridor not required during the operational phase, to be rehabilitated and revegetated with local native plant species immediately after construction has been completed. The proposed delayed rehabilitation of these sections at mine closure, estimated to be at least 300 ha in size, was deemed an unacceptable environmental risk by the NT EPA.

The NT EPA supports the Proponent's commitment to implement appropriate erosion and sediment controls to minimise the erosion risk.

Recommendation 9

That the Proponent rehabilitate and revegetate all sections of the infrastructure corridor not required during the operational phase shortly after construction has been completed. Revegetation is to use local native plant species.

Lateral, above-ground seepage from surface TSF

The surface TSF will be constructed to ANCOLD standard (ANCOLD, 2012) and walls will be lined to prevent above-ground seepage.

Recycled process water being used for dust suppression

Chemical analysis of two synthetic tailings samples indicated that tailings leachate and decant would have a slightly alkaline pH and slightly elevated SAR, fluoride, phosphorous and molybdenum, which may increase soil dispersion and impact crop yield and nutrient load when used in an agricultural setting. If used for dust suppression, tailings leachate and decant water do not present a significant risk to the environment unless used on a large scale adjacent to waterways. The latter would be unlikely to occur as there is no surface water within the vicinity of mining operations. Construction of the infrastructure corridor would use groundwater and not process water, which is unlikely to impact ephemeral wetlands if used for dust suppression in the small sections adjacent to these wetlands.

Surface runoff within the mine site, including runoff from ore and phosphate rock concentrate stockpiles

Stockpiles of phosphate rock concentrate will be covered and therefore rarely produce runoff. Runoff from ore stockpiles will have elevated metal concentrations relative to the 95% aquatic ecosystem protection levels (see section 5.2.4). There are no surface water bodies within the proposed mine site, and any contact with surface waters would be through an uncontrolled discharge (see discussion above).

Fuel and chemical spills

The risk of spills of hazardous material, including fuel and chemicals, contaminating surface waters was assessed in the EIS as low and mainly associated with the construction of the infrastructure corridor, transport and other mining-related activities offsite, as there are no surface waters within or downgradient of the mine site. The risk will be managed through appropriate handling, storage and transport of hazardous materials outlined in the Hazardous Substances Management Plan and in compliance with relevant legislation and standards. Accidental spills will be managed in accordance with the Emergency Response Management Plan and the Environmental Investigation Procedure.

Potential impacts to soils are discussed in Appendix 2 (terrestrial environmental quality).

The NT EPA reminds the Proponent of its obligation not to cause environmental harm. Any uncontrolled discharge or spill must be reported to the relevant regulator.

5.2.4.3 Summary and conclusion

The Proponent proposes to deposit tailings permanently in unlined facilities. The justification not to line these was based on preliminary geochemical characterisations of two synthesised tailings samples and about 200 waste rock samples. Chemical assays indicated that mined and processed materials are unlikely to generate saline, acid and metalliferous drainage, and that any leachate is unlikely to significantly impact groundwater quality.

Overall, the NT EPA assessed the risk of groundwater contamination from unlined tailings storage facilities as low, based on:

- a low likelihood for mined and processed materials and their leachates to generate saline, acid and metalliferous drainage and hence a limited inventory of potentially leachable contaminants
- deep groundwater levels in the region, including underneath the mine site, with the potential for leachable materials to be attenuated in the regolith overlying the groundwater table
- a multi layered precautionary management approach to avoid, monitor, audit and mitigate any remaining risks of contamination
- the regulatory controls in place should seepage exceed the agreed thresholds.

However, the NT EPA acknowledged there is some uncertainty about the geochemical composition of tailings, due to the limited number of synthesised tailings samples investigated and that actual tailings have not been analysed. The NT EPA is of the opinion that a precautionary approach should be used, especially in the early stages, to decrease the risk for environmental harm to occur. In addition to the proposed management, monitoring and mitigation measures, the NT EPA recommends:

- the Proponent conduct aggressive tailings leach testing prior to mining and extract and analyse actual tailings seepage and decant water during the first 12

months of operation. The results will inform the requirement for any mitigation options such as lining and tailings treatment

- frequent geochemical and radiological testing of the waste rock, tailings, ore and their leachates as potential sources for groundwater contamination
- the incorporation of all recommendations from the independent peer review and the commitments made by the Proponent into the respective management plans
- an assessment of the contamination potential of chemicals added during water treatment and beneficiation process, in particular of the flocculants
- the development of an AMD contingency plan recognizing that if tailings seepage exceeds the agreed threshold levels then mitigation options such as lining of the tailings storage or additional tailings treatment must be implemented immediately
- independent external audits of the groundwater quality monitoring program.

The NT EPA assessed the contamination risks to surface waters as low based on:

- an absence of surface water drainage features within the proposed mine site
- appropriate preventative measures, monitoring programs and contingency plans to prevent contamination of downgradient surface waters through an accidental spill or unplanned discharge.

With the implementation of the relevant management plans and recommendations identified above, the NT EPA considers the Proposal could be conducted in such a manner that its objective for inland water environmental quality is likely to be met.

6 Whole of environment considerations

The purpose of this section is to evaluate other important matters relating to the potential impacts of the Proposal on the environment that are fundamental to the environmental acceptability of this Proposal.

6.1 Rehabilitation and closure

The Proponent has provided a conceptual Closure Report (updated in the Supplement, Appendix 1) that outlines closure concepts and tasks. The Proponent committed to the development of a detailed Rehabilitation Plan, including completion criteria, which would inform the content of a Mine Closure Plan (MCP) to be incorporated into the MMP required as part of the authorisation process under the *MM Act*.

A key component of the closure concept is progressive rehabilitation of mined-out pits, that would commence after year one and continue throughout the life of the mine. The NT EPA supports this concept and emphasises the importance of early planning for mine rehabilitation and closure. The NT EPA considers that closure plans should align with leading practice (e.g. (DIIS, 2016); DMP, 2015) and satisfy the principles of the International Council of Mining and Metals Mine Closure Guidelines (ICMM 2015).

The Proponent acknowledges that the phosphate deposit is much larger than the resource being targeted in this Proposal. Consequently, the NT EPA considers that some of the proposed infrastructure and mine components may be present in the landscape for substantially longer than described in the current Proposal, subject to future assessment. The NT EPA considers that closure planning should require such components be managed for long-term persistence, with appropriate rehabilitation of surrounding areas.

The NT EPA supports the proposed progressive rehabilitation and expects it to be an integral part of the Mine Closure Plan to ensure sustainable rehabilitation and closure are thoroughly considered prior to authorisation of the Proposal. The NT EPA

recommends that rehabilitation outcomes, including revegetation, to be audited every five years to ensure best practice is applied to rehabilitation and revegetation is developing towards self-sustaining ecosystems.

Recommendation 10

That approvals and decisions for the Proposal have conditions that require the Proponent to provide a Mine Closure Plan to the relevant regulator prior to mining. The Mine Closure Plan must:

- be of a standard equal to or better than the Western Australian guidelines for preparing mine closure plans (DMP, 2015)
- address all aspects of rehabilitation and mine closure, including post-mining land use agreed with stakeholders, rehabilitation objectives, schedules for progressive rehabilitation, completion criteria and monitoring of rehabilitation success
- include predicted landform designs that are consistent with current standards and best practice
- include plans and a schedule for post-construction rehabilitation of all areas of the infrastructure corridor that would no longer be required after construction
- demonstrate that all rehabilitated areas would be safe to humans and animals, geotechnically stable, non-polluting and non-contaminating, and capable of sustaining the agreed post-mining land use
- include details of the research trials and investigations that would inform, guide and support appropriate landform covers and ecosystems for all rehabilitation, including progressive rehabilitation and closure
- investigate the long term settling process of tailings and waste rock to inform construction of appropriate landform covers and avoidance of significant depressions and pooling of water
- provide details of a program for regular monitoring and reporting on the performance of progressive rehabilitation works
- provide for results from monitoring the performance of progressive rehabilitation to inform decision-making to ensure long-term successful rehabilitation
- outline a strategy for appropriate consultation with stakeholders on rehabilitation objectives and post-mining land use
- provide for ongoing monitoring and maintenance of the site post-mining, in accordance with an approved monitoring and maintenance program, until such time as the relevant regulator directs
- require reporting to the relevant regulator on progressive rehabilitation works and performance
- require independent external audits by suitably qualified and experienced professionals of the progressive rehabilitation, including revegetation, at least every five years and at closure.

The Mine Closure Plan is to be peer-reviewed by an appropriately qualified independent professional prior to submission to the relevant regulator.

The NT EPA recognises that mine rehabilitation and closure planning would continue to evolve through the life of the mine. The Mine Closure Plan should be subject to regular

review, development and improvement throughout the life of the mine including any period of care and maintenance, as specified in Recommendation 11. The NT EPA considers the Proponent should provide alternative rehabilitation options in future iterations of the Mine Closure Plan as relevant site-specific information is collected and technology and management techniques evolve over time. It should include a comparison of the long term or residual environmental risk between the current conceptual closure plan and other alternatives that may address long-term risks to the environment.

Recommendation 11

That approvals and decisions for the Proposal have conditions that require future iterations of the Mine Closure Plan to include:

- **alternative rehabilitation options that identify a range of closure scenarios and strategies for the mine pit and associated infrastructure and provide justification that the preferred closure option minimises environmental risks**
- **identification and management of knowledge gaps relating to closure-specific technical information (including environmental baseline data, waste characterisation, and review of monitoring data) to inform sustainable mine closure**
- **details of pre-closure research trials, investigations and modelling aimed at addressing knowledge gaps to inform detailed rehabilitation design. These are to include, but are not limited to, vegetation, final cover materials, capping design, and surface water runoff.**

6.2 Community engagement

The NT EPA considers that stakeholder and community engagement should be ongoing through the life of the mine, from the early planning phases to mine closure and relinquishment. All members of the community who are likely to affect, to be affected by, or to have an interest in the Proposal should be identified and appropriately consulted.

The Proponent identified a range of stakeholders in the Proposal and indicated in the EIS that some community consultation had taken place between 2013 and 2017. The NT EPA notes that a submission from the Central Land Council (CLC) on the Draft EIS expressed concern regarding the level of consultation undertaken by the Proponent, especially with local Aboriginal people (Supplement). The CLC represents the native title holders of areas that would be affected by the Proposal, who may negotiate an Indigenous Land Use Agreement.

The NT EPA considers that ongoing stakeholder engagement between the Proponent and the local and broader community is essential to ensure post mining land uses, closure and rehabilitation objectives, and completion criteria are agreed in accordance with leading practice (DIIS, 2016; ICMM 2015; ICMM, 2016).

The Proponent has stated its commitment to develop and/or maintain relationships with stakeholders, including indigenous communities, for the life of the mine. The Economic and Social Impact Management Plan (ESIMP) outlines a community advisory group to facilitate this. The NT EPA considers that engagement with the local and broader community, in an open and transparent manner, to be important to establish a social licence for mine operations. The NT EPA considers that a consultation group should be formalised, with all parties understanding the purpose of consultation and their own role in it.

Recommendation 12

That approvals and decisions for the Proposal include conditions that require the Proponent to demonstrate appropriate engagement with native-title holders, and to establish a Community Consultation Group with Aboriginal, pastoral, and other relevant stakeholders to provide a forum to:

- inform (in an appropriate manner) local residents of key aspects of the Proposal that may impact on their values, including amenity and cultural practices
- consult with local residents and relevant agencies on matters relating to the proposed workforce, to maximise benefits for local employment, and to manage cumulative impacts on demand for local workers and overall employment opportunities
- undertake ongoing stakeholder consultations on agreed post-mining land use and rehabilitation objectives.

7 Conclusion

The NT EPA's assessment of the proposed Ammaroo Phosphate Project identified potentially significant environmental impacts and risks associated with the proposed water abstraction, the limited geochemical characterisation of tailings, and rehabilitation and closure.

The NT EPA considers that, subject to the implementation of the 12 recommendations in this Assessment Report and the commitments and safeguards listed by the Proponent in the EIS, the Proposal can be implemented and managed in a manner that is likely to meet the NT EPA's objectives and avoid significant or unacceptable environmental impacts and risks.

8 References

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Appendix 1 - Geographic coordinates defining the Proposal Area

Geographic coordinates defining the Proposal area:

Location point	Latitude	Longitude
MLA 29854		
1	21° 27' 0.000" S	135° 5' 0.000" E
2	21° 32' 0.000" S	135° 5' 0.000" E
3	21° 32' 0.000" S	135° 9' 0.000" E
4	21° 27' 0.000" S	135° 9' 0.000" E
ML29463		
1	21° 27' 0.000" S	135° 9' 0.000" E
2	21° 32' 52.613" S	135° 9' 0.000" E
3	21° 32' 52.228" S	135° 14' 29.188" E
4	21° 28' 38.525" S	135° 14' 28.766" E
5	21° 28' 38.708" S	135° 12' 9.767" E
6	21° 27' 0.000" S	135° 12' 9.630" E
Transport Corridor		
1	21° 11' 56.714" S	134° 8' 26.508" E
2	21° 13' 56.400" S	134° 7' 34.746" E
3	21° 15' 50.123" S	134° 13' 54.857" E
4	21° 27' 19.116" S	134° 44' 55.209" E
5	21° 26' 31.173" S	134° 56' 54.139" E
6	21° 29' 41.617" S	135° 7' 41.554" E
7	21° 28' 57.564" S	135° 8' 42.785" E
8	21° 27' 45.064" S	135° 8' 19.213" E
9	21° 24' 21.571" S	134° 57' 16.172" E
10	21° 25' 8.265" S	134° 45' 10.692" E
11	21° 13' 48.390" S	134° 14' 43.890" E
12	21° 11' 56.714" S	134° 8' 26.508" E

Appendix 2 – Assessment of the NT EPA's environmental factors

The NT EPA assessed the environmental impact of the Proposal in line with its environmental factors and objectives (NT EPA, 2018). The following table presents environmental factors for the Proposal which, based on current knowledge, were assessed as not significant. The NT EPA considers it unlikely that implementation of the Proposal would have a significant impact on these factors and they can be managed to meet the NT EPA's environmental objective.

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
LAND		
Terrestrial Flora and Fauna	1. Clearing of 3775 ha of native vegetation. 2. The grey falcon, is likely to occur in the Proposal area. 3. Discovery of threatened species	1. The proposed clearing is unlikely to have a significant impact on fauna or flora for the following reasons: • The vegetation communities that would be cleared are relatively common in the region. • No threatened fauna or flora species were recorded within the areas to be cleared, and expert advice was that the areas to be cleared are unlikely to be important habitat for threatened species. • A small area (size inferred from mapping) of ephemeral wetlands and drainage floors (sensitive vegetation as per definition in DLRM, 2017 and NRETAS, 2010) would be cleared. • No groundwater dependent vegetation occurs in the Proposal area. 2. The grey falcon is widespread in low densities across the arid and semi-arid area of Australia. The vegetation to be cleared is suitable foraging habitat for the grey falcon, but contains very little suitable nesting habitat. The NT EPA considers the risk of impact to this species from habitat removal to be minimal, especially due to the staged mining approach with progressive rehabilitation. 3. Should a threatened species be sighted or found within or near the proposed mine site and infrastructure corridor, the finding should be reported to the Department of

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
	4. Fauna entrapment There is some potential for fauna mortality from entrapment in trenches required for the gas pipeline construction. 5. Contaminated water Standing water associated with the tailings storage facility and in-pit tailings disposal could contain contaminants that could impact native fauna species by contact or consumption. 6. Vehicle strikes Fauna may be killed or injured by strikes from vehicles used for the Proposal on roads and rail.	Environment and Natural Resources (DENR) and appropriate mitigation measures should be implemented to the satisfaction of DENR. 4. The Proponent outlined a number of commitments in the EIS that would avoid impacts to fauna during pipeline construction. These would be included in the Biodiversity Management Plan to be implemented as part of the Mining Management Plan (MMP) to be authorised under the <i>Mining Management Act</i> (MM Act). As the measures are proven to be effective at other trenching developments in the NT, the NT EPA considers these would be appropriate for managing this potential impact. However, the Mole Ploughing method now proposed for laying the pipeline does not leave any open trench. 5. The Proponent committed to periodically remove free standing water, design the TSF to discourage wildlife, monitor wildlife visitation, and develop management responses if necessary. Additionally, preliminary testing indicated that most water quality parameters would be within drinking water guidelines for sensitive livestock, with the exception of pH and fluoride (see section 4.3 for further detail). The NT EPA considers that these commitments are adequate and appropriate for preventing, mitigating or managing this potential impact. The NT EPA expects this to become a standard operational control of the mine. 6. The Proponent's Biodiversity Management Plan and Traffic Management Plan would be part of an EMP, and would include reporting of injured and killed fauna species and limiting the movement of vehicles at night when fauna are more likely to be active. The Proponent also committed to updating the plan to provide additional traffic management protocols should susceptible threatened species (e.g. greater bilby) be found on or near the site. The NT EPA considers that implementation of the EMP would adequately mitigate this potential impact on most fauna and expects it to become standard practice, noting that additional mitigation measures may be required if threatened fauna are detected

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
	7. Introduction and spread of weeds The Proponent identified 13 weed species in the Proposal area, including the declared weed <i>Calotropis procera</i> (rubber bush), as well as the invasive pasture grass <i>Cenchrus ciliaris</i> (buffel grass) (DoE, 2015). Implementation of the Proposal could assist the distribution of these species or introduce new species. Any weed species can alter the composition of native vegetation (and thereby potentially alter fauna habitat suitability) by competition and/or other mechanisms such as changing the fire regime. 8. Competition/predation from introduced fauna The Proposal would introduce new sources of water (and potentially food) to the landscape that may increase the density of non-native fauna that compete with, or predate on, native fauna.	7. The Proponent committed to develop a Weed Management Plan, which would require implementation as part of the MMP. The NT EPA considers that this is appropriate for managing this potential impact and expects it to become standard practice. 8. The Proponent committed to the inclusion of monitoring and control of feral species in the Biodiversity Management Plan. The NT EPA considers that this is appropriate for mitigating this potential impact and expects it to become standard practice. <u>Conclusion</u> The NT EPA considers that the risks to threatened fauna or flora, fauna biodiversity, and significant vegetation communities are generally low, and potential impacts can be further avoided, mitigated or managed through the implementation of commitments and management plans that would be regulated under the MM Act.

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
Terrestrial environmental quality	1. Soil contamination 2. Erosion and sediment movement 3. Rehabilitation failure	1. Contamination of soils would occur through similar pathways to contamination of groundwater and surface waters, assessed in section 5.2. The NT EPA considers that the proposed monitoring and management programs are appropriate for preventing and mitigating this potential impact and expects it to become standard practice. 2. The Proposal would implement erosion and sediment controls, including a regulator-endorsed and audited ESCP, for all aspects and stages of the mine's operation and closure. These would form part of the MMP and be subject to a monitoring plan. Post-closure monitoring would include assessment of the physical and geotechnical stability of post-closure landforms and rehabilitation/revegetation success. The NT EPA considers that this is appropriate for preventing and mitigating this potential impact and expects it to become standard practice. 3. A peer-reviewed Mine Closure Plan and a mining security bond would be required as part of the authorisation process under the MM Act to prevent rehabilitation failure. See section 2.2.6 for an overview of the closure process and section 6 for further discussion of rehabilitation and closure and recommendations. The NT EPA considers that this is appropriate for mitigating this potential impact and expects it to become standard practice. <u>Conclusion:</u> With the implementation of the proposed preventative measures, monitoring programs, mitigation measures and relevant management plans identified above, the NT EPA considers that the Proposal could be conducted in such a manner that its objective for terrestrial environmental quality is likely to be met.
Landforms	There are no distinctive physical landforms in the area of the Proposal.	It is unlikely that implementation of the Proposal will impact on landforms.
WATER		

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
Aquatic Ecosystems	There are no aquatic ecosystems in the Proposal area.	There may be aquatic ecosystems downstream from the Proposal area, but not close enough to be potentially impacted via water flowing from or through the Proposal area. It is unlikely that implementation of the Proposal would impact on aquatic ecosystems. See section 5.2.3.2 for an assessment of potential impacts to surface water quality.
AIR		
Air quality and greenhouse gases	1. Dust generation Dust would be generated by wind over disturbed or cleared areas, mining activities (excavation, loading, grading, hauling), beneficiation, and by vehicle movement on dirt roads. 2. Greenhouse gas emissions Implementation of the Proposal would result in the unavoidable emission of greenhouse gases from land clearing, construction, vehicle emissions, and energy generation.	1. Modelling provided by the Proponent predicted that dust generated by implementation of the Proposal is unlikely to impact on air quality at the nearest offsite sensitive receptors (i.e. unlikely to be detectable over background conditions). These include Ampilatwatja community and Double D outstation, located about 12 km (upwind under the most common conditions) and 25 km (downwind), respectively, from the mineral lease. The Proponent has stated that dust generation would be avoided, minimised and controlled using standard procedures that would be specified in a Dust Management Plan (Draft EIS, Chapter 15.5). The Proponent intends to establish a monitoring site at the proposed accommodation village, about 3.5 km from dust-generating areas of the Proposal. This would enable evaluation of dust modelling predictions. The NT EPA considers that this is appropriate for avoiding or managing potential impacts of dust on air quality and expects dust management to become standard practice. 2. The clearing of 3775 ha of native vegetation (generally sparse vegetation ranging from low woodlands, shrublands to grasslands of low biomass per hectare) will not result in greenhouse gas emissions that are significant on a national or regional scale. Emissions from vehicles will not be significant on a national scale. The largest contribution to greenhouse gas emissions would be from the consumption of energy via gas fired power generation and gas-fired drying of phosphate produce, which is expected to be 3.2 PJ/y. The NT EPA calculated that this equates to GHG emissions of 164 896 t CO₂ –e and represents 1% of the total and 4.34% of the stationary energy GHG emissions produced in the NT in 2016 (DoEE, 2018).

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
		The Proponent has stated that high efficiency gas engines would be used, and solar power would be used if possible for some parts of the Proposal. The Proponent is seeking alternative options for the drying of phosphate product that would reduce energy consumption and result in fewer greenhouse gas emissions. The NT EPA supports the Proponents intention to increase energy efficiencies and the proportion of energy supplied by renewable sources, which would minimise greenhouse gas emissions associated with implementation of the Proposal. <u>Conclusion</u> The NT EPA concluded that there is not likely to be significant impacts to air quality for sensitive receptors. The potential impacts could be avoided, mitigated or managed through the implementation of a Dust Management Plan that would be regulated under the <i>MM Act</i>. The assessment also concluded that greenhouse gas emissions from implementation of the Proposal are unavoidable but would be minimised through the use of high-efficiency generators and potentially reduced further by using renewable energy sources.
PEOPLE AND COMMUNITIES		
Social, economic and cultural surroundings	1. Degradation of cultural values associated with sacred sites 2. Degradation of cultural values associated with archaeological sites/artefacts	1. The Proponent has applied for an Authority Certificate to be issued in accordance with the <i>Northern Territory Aboriginal Sacred Sites Act</i> (NTASS Act). Issuing of the certificate is a matter for the Aboriginal Areas Protection Authority. The Proponent has committed to conducting works in accordance with the Authority Certificate. If the Proposal is implemented in accordance with a valid Authority Certificate issued under the NTASS Act, the NT EPA considers that this potential impact would be mitigated. 2. The Proponent presented a draft Cultural Heritage Management Plan (CHMP) with commitments to include an Unexpected Heritage Finds Procedure and to have the CHMP endorsed by the Heritage Branch of the Department of Tourism and Culture prior to the commencement of construction. The NT EPA considers that this potential impact would be avoided, mitigated and managed through implementation of the

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
	3. Reduced access to land for traditional use by Aboriginal people There is potential for the infrastructure corridor to restrict access to land used for traditional hunting and gathering practices of importance to Aboriginal people 4. Reduction in local landscape amenity The Proposal would result in increased traffic on roads in the region, with associated dust and noise that could detract from the quiet, relatively natural feel of this remote area and reduce the operational performance of roads. 5. Changes to local socio-economic conditions	CHMP, subject to the commitments made by the Proponent. The CHMP will form part of the MMP, to be regulated under the <i>MM Act</i>. 3. The Proponent stated in the Supplement that they would discuss this matter further with Aboriginal people. The NT EPA has further assessed the issue of community consultation in section 6.2 of this Report. 4. The NT EPA notes that the proposed realignment of Murray Downs Road is currently under discussion and would be subject to the standard assessment and approval processes of the road authority. The Proponent stated that it will develop and implement a Traffic Management Plan and an inspection and maintenance agreement with the relevant road authority. The NT EPA considers that this would enable the mitigation of potential impacts on road-related aspects of the Proposal. Implementation of the Proposal would also result in permanent alteration of the landscape, which could impact on the spiritual and/or cultural value of the landscape to local Aboriginal people (as reflected in the local art movement) and local pastoralists. To manage this impact, the NT EPA considers that community consultation on post-mining land use objectives and closure planning would be essential. This is discussed in section 6 of this Report. 5. The NT EPA supports the Proponent's goals to source some workers from the local region, as this could provide economic and social benefits. There is also potential for negative impacts on community cohesion and community resilience due to, for example, inequitable distribution of economic benefits or unmet expectations. To avoid or manage these and other potential economic and social impacts, the Proponent will implement an Economic and Social Impact Management Plan (ESIMP). The draft ESIMP provided in the draft EIS outlined measures such as a

Environmental Factor	Potential impacts	Explanation of why the factor is not a key environmental factor
		community advisory group, workplace and employment plan, grievance register, Local Industry Participation Plan, Code of Conduct and cultural inductions for workers. The NT EPA considers that implementation of the ESIMP would facilitate the mitigation and management of these potential impacts, but also stressed the importance of community consultation in achieving this, as discusses in section 6 of this Report. <u>Conclusion</u> The assessment concluded that some potential social, economic and cultural impacts can be addressed through legislative processes including the implementation of operating plans as part of regulation under the MM Act. Some potential impacts will require effective community consultation for their mitigation and management. This is addressed in section 6 of this Report.
Human health	Implementation of the Proposal could result in potential impacts to human health via water, land, or air contamination, or through decreased community resilience.	The NT EPA considers that these would be avoided or managed through addressing the environmental factors (and achieving their objectives) for Inland water environmental quality; Terrestrial environmental quality; Air quality and greenhouse gases; and Social, economic and cultural surroundings. In addition, potential impacts to human health will be managed through a health and safety management system guided by WorkSafe Australia and AS/NZS 4801:2001 Occupational Health and Safety Management Systems (Standards Australia, 2001). The approach was confirmed by NT WorkSafe, Department of the Attorney - General and Justice.

Appendix 3 – Principles of Ecologically Sustainable Development

Under the NT EPA Act, ecologically sustainable development (ESD) means using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life now and in the future can be increased.

In December 1992, the Territory Government endorsed the 'National Strategy for Ecologically Sustainable Development' and agreed, along with all other States and Territories, to the 'Intergovernmental Agreement on the Environment' (IGAE) (Australian Government 1992).

The NT EPA uses the four principles contained in the IGAE to demonstrate that it has considered ESD in its assessment of the Proposal and in fulfilment of its objectives under the NT EPA Act.

ESD Guiding principle	NT EPA assessment
1. The precautionary principle <i>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.</i> <i>In application of this precautionary principle, decisions should be guided by:</i> <i>a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and</i> <i>b) an assessment of the risk-weighted consequences of various options.</i>	In considering this principle, the NT EPA notes that Hydrological Processes and Inland Waters Environmental Quality could be significantly impacted by the Proposal. The assessment of these impacts is provided in this report. The Proponent's investigations into the physical, biological and cultural environment provided sufficient scientific certainty to enable assessment of the risks and potential impacts and to identify measures to avoid or minimise those impacts and risks. The NT EPA made recommendations to ensure these measures to prevent environmental degradation recommendations of independent peer reviews are implemented by the proponent, including the use of independent peer reviews. In addition, the NT EPA made recommendations in line with the precautionary principle in order to prevent and minimise impacts, such as water table drawdown at the Georgina Basin carbonate aquifer and seepage to the aquifer underneath the mine site. From its assessment of the Proposal, the NT EPA concluded that if its recommendations are imposed as conditions on the implementation of the Proposal, there is no threat of serious or irreversible damage.
2. The principle of intergenerational equity	The NT EPA notes that only the measured portion of the phosphate deposit is subject to this proposal, with the life of the mine potentially extending beyond the proposed 25 years. While any alterations with significant consequences to the

<i>The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.</i>	environment would require additional assessment, the NT EPA expects that the measures proposed by the proponent to avoid and minimise long term impacts of the Proposal on the environment would be progressively improved as further knowledge becomes available through the proposed monitoring programs and management frameworks. From its assessment of this Proposal, the NT EPA concluded that, provided its recommendations are imposed as conditions on the implementation of the Proposal, environmental values will be protected and that the health, diversity and productivity of the environment will be maintained for the benefit of future generations.
3. The principle of the conservation of biological diversity and ecological integrity <i>Conservation of biological diversity and ecological integrity should be a fundamental consideration.</i>	In considering this principle, the NT EPA notes that the Proposal will result in impacts and risks to Hydrological Processes and Inland Waters Environmental Quality. In assessing this proposal, the NT EPA has considered these impacts and risks and taken into consideration measures proposed by the proponent to avoid and minimise impacts to the affected values. From its assessment of this proposal the NT EPA has concluded that, provided its recommendations are imposed as conditions on the implementation of the proposal, the proposal will not compromise the biological diversity and ecological integrity of the affected areas.
4. Principles relating to improved valuation, pricing and incentive mechanisms a) <i>Environmental factors should be included in the valuation of assets and services.</i> b) <i>The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.</i> c) <i>The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.</i>	In considering this principle, the NT EPA notes that the Proponent would take responsibility for preventing, managing and mitigating waste and pollution, including contamination of soils, groundwater and surface waters through accidental spills, uncontrolled discharges and tailings seepage. All stages of the Proposal, including rehabilitation, mine closure and decommissioning, would be the responsibility of the Proponent. The NT EPA has had regard to this principle during the assessment of the proposal.

d) <i>Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimize costs to develop their own solution and responses to environmental problems.</i>	
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Appendix E

Detailed Fertiliser Flow Diagram

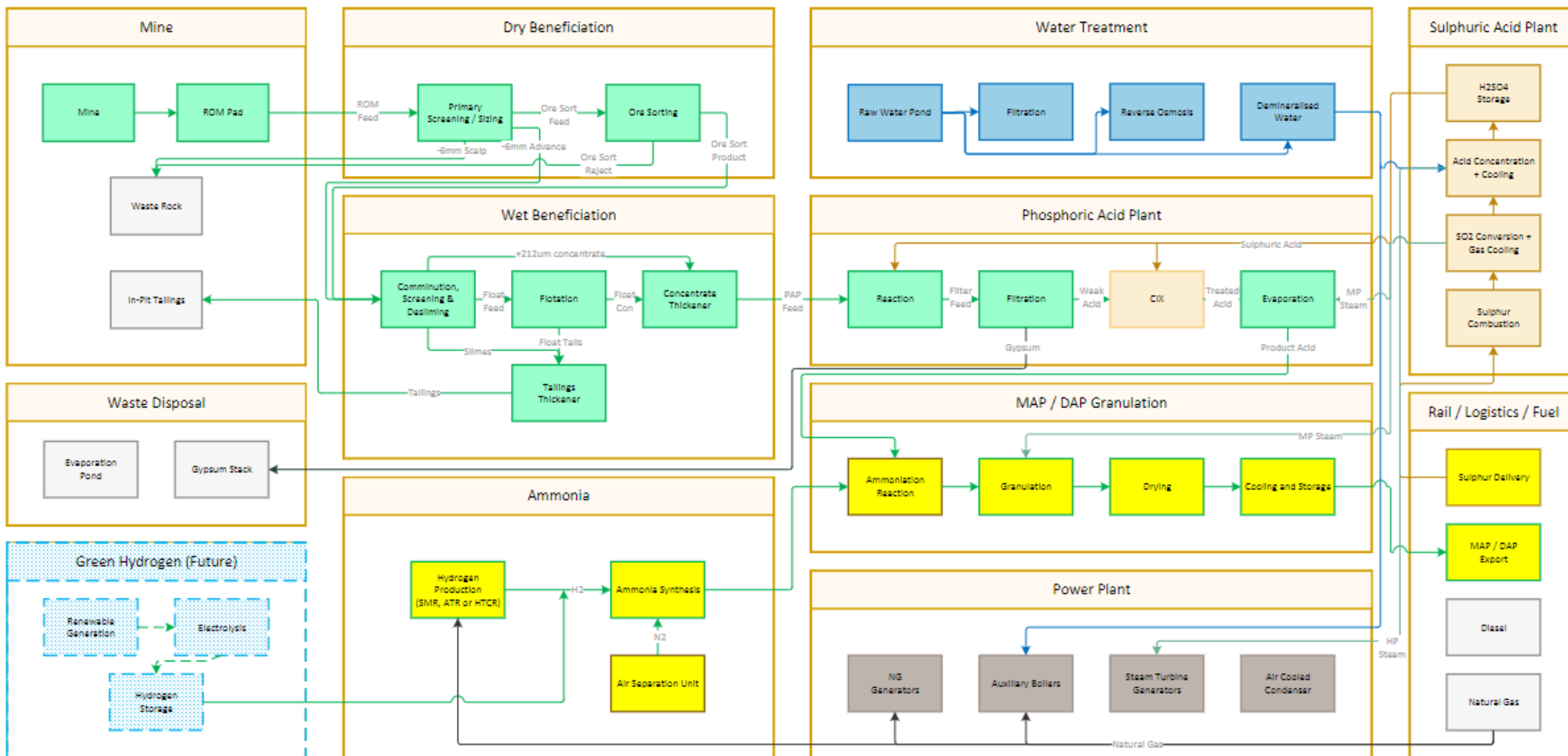


Figure A 1: Process Flow Diagram for Fertiliser Plant (Ammaroo Ammonium Phosphate Fertiliser Project interfaces)

Appendix F

Risk Register

Risk Assessment Methodology

The environmental risk analysis was undertaken to:

- Establish a risk framework that defined boundaries of risk likelihoods and consequences.
- Identify the type of risks associated with the project.
- Analyse the identified risks.
- Evaluate the risks by rating them according to the likelihood of the risk and its consequence.
- Outline management measures to mitigate risks to an acceptable level.
- Determine the residual level of risk after application of management measures.

The first step involves the identification of the consequence levels should a particular risk result in a negative impact. These are summarised in Table A 3.

The second step involves defining the risk categories. This considered the frequency of activities that may cause the impact and likelihood (probability) of the impact occurring during the activity. The level of likelihood that a risk would occur is summarised in Table A 4.

The risk rating category of each potential impact was then determined by combining the likelihood with the consequence of the risk according to the matrix shown in Table A 5.

Table A 3 Risk consequence definitions

Risk	Negligible - 1	Minor - 2	Moderate - 3	Major - 4	Severe - 5
Environment and Heritage	No measurable impact.	Minor Impacts on flora / fauna and habitat but no negative impacts to ecosystem function.	Policy or contractual breach.	Legislative, regulatory or policy breach.	Major legislative. Regulatory or policy breach.
	Limited / minimal damage to areas of low significance.	Minor impacts with no permanent or lasting detrimental effects to the environment or cultural or social values.	Significant localised impacts without long term detrimental environmental or social impacts.	Significant widespread environmental effects with long term detrimental environmental or social impacts.	Significant extensive environmental effects with long term detrimental environmental or social impacts.
			Short term or repairable adverse effects to ecosystem function or endangered / beneficial species, habitat, or cultural & heritage values.	Localised eradication or significant impact to ecosystem function, endangered / beneficial species, habitat, or cultural and heritage values.	Widespread, permanent, and persistent damage to ecosystem function or area of significance including cultural heritage values.
					Eradication of endangered/beneficial species or habitat.

Table A 4 Risk likelihood definitions

Level	Descriptor	Likelihood of Occurrence
1	Rare	May occur in exceptional circumstances.
2	Unlikely	Could occur at some time
3	Possible	Might occur at some time
4	Likely	Will probably occurs in some circumstances
5	Almost Certain	Expected to occur in most circumstances

Table A 5 *Risk rating matrix*

Likelihood Rating	Consequence Rating				
	Negligible 1	Minor 2	Moderate 3	Major 4	Severe 5
Rare 1	Low 1	Low 2	Low 3	Low 4	Low 5
Unlikely 2	Low 2	Low 4	Medium 6	Medium 8	Medium 10
Possible 3	Low 3	Medium 6	Medium 9	High 12	High 15
Likely 4	Low 4	Medium 8	High 12	High 16	Extreme 20
Almost Certain 5	Low 5	Medium 10	High 15	Extreme 20	Extreme 25

Table A 6 *Risk rating categories*

Risk category	General description
Low	Potential impacts either require no specific management measures or can be directly managed through design measures, general mitigation measures and safety controls.
Medium	Management responsibility required. Potential impacts can be mitigated through the application of relatively standard environmental management measures.
High	Management attention needed. Detailed assessment and planning are necessary to develop appropriate measures to mitigate and manage the potential impacts associated with the risk.
Extreme	Immediate action required. Detailed assessment and planning are necessary to develop appropriate measures to mitigate and manage the potential impacts associated with the risk.

Risk Register

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
1. Land													
1.1 Landforms Conserve the variety and integrity of distinctive physical landforms.	Gypsum stacking facility	Yes	Visual amenity	Visual amenity and site natural aesthetics compromised by GSA	All	Gypsum stack altering landforms to create a visual change for sensitive receptors or places of natural value.	11 - Moderate	3 – Likely	14 - Medium	- A closure plan will be submitted at the mine management plan stage. - Decommissioning and dismantling of physical plant will occur as agreed. - Rehabilitation and revegetation will also be undertaken as agreed in the Mine Management Plan.	16 - Minor	7 – Unlikely	23 - Low
1.2 Terrestrial environmental quality Protect the quality and integrity of land and soils so that environmental values are supported and maintained	Gypsum stacking facility	Yes	Ecosystems, groundwater, and surface water	Failure of post-closure gypsum rehabilitation/ closure, leading to erosion or seepage loss of material to the environment.	Decommissioning	A reduction in habitat quality leading to reduced diversity of flora and fauna species.	11 - Moderate	3 – Likely	14 - Medium	- As part of the Mine Management Plan, an updated mine closure plan including gypsum stack area (GSA) will be submitted. - A site-specific water management plan describing the procedures to be employed during closure of the system to manage the anticipated volume of process wastewater will be updated. - An estimate of all costs associated with closure of the system, including the costs of closing, any long-term care, and implementation of the site-specific water management plan - A description of all construction work necessary to properly close the system	16 - Minor	7 – Unlikely	23 - Low
1.3 Terrestrial ecosystems Protect terrestrial habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning	Vegetation clearing	Yes	Ecosystems	Loss of vegetation due to land clearing	Construction and Operation	A reduction in habitat quality leading to a decrease in the diversity and/or abundance of flora and fauna species	11 - Moderate	1 – Almost Certain	12 - High	- Limit the disturbance of areas required for the airfield and associated access road, expansion of the Accommodation Village, and installation of additional boreholes in the bore field, within the overall disturbance area of Approved Project (although there is a small increase in the disturbance footprint in these localities). - Erosion and Sedimentation Control Plan will be updated for the Proposed Project and	11 - Moderate	5 – Possible	16 - Medium

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										outline management of soil to minimise erosion and sedimentation - On-going rehabilitation of cleared land from year 1. It is noted that the Proposed Project will result in no significant additional clearing compared to the Approved Project. There may be additional land clearance required for installation of renewable (wind and solar) associated with meeting a full GGAP. This to be defined at a later stage.			
	Vehicles and machinery onsite		Ecosystems	Mortality of flora and fauna due to interactions with machinery used in land clearing	Construction and Operation	Decrease in the diversity and/or abundance of flora and fauna species, particularly of some species that are less able to, or are reluctant to, evacuate their hiding places prior to them being cleared – such as nesting birds, nocturnal animals, and smaller reptile and mammal species that hide in burrows or tree hollows.	16 - Minor	3 – Likely	19 - Medium	- Vegetation Clearing Procedure and Site Traffic Management Plan will be updated for the Proposed Project. -The Proposed Development will not result in significant additional clearing compared to the Approved Project.	16 - Minor	3 – Likely	19 - Medium
	Bushfires		Ecosystems	Increased frequency of bushfires caused by machinery or personnel	All	Large scale reduction in ecosystem integrity.	6 - Major	7 – Unlikely	13 - Medium	Bushfire Management Plan will be updated for the Proposed Project and include: - All construction activities, including establishment and operation of temporary camps, will occur within a cleared project footprint to minimise the risk of ignition sources coming into contact with flammable material (such as cleared vegetation). - Fire ratings and warnings in the area will be monitored and the proponent will liaise with Bushfires NT as required. - Fire breaks will be established.	11 - Moderate	9 – Rare	20 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
2. Water													
2.1 Hydrological processes Protect the hydrological regimes of groundwater and surface water so that the environmental values including ecological health, land uses, and the welfare and amenity of people are maintained.	Groundwater extraction	Yes	Groundwater and users	Drawdown of shared groundwater aquifers to supply Proposed Project e.g., Hagen's bore and community water supplies (i.e. Ampilatwatja)	Construction and Operation	Changes to flux across the boundary of the Western Davenport Water Control District that results from the simulated extraction (predicted to peak at 0.6 ML/day)	21 - Negligible	7 – Unlikely	28 - Low	- No control measures are required based on the updated GW modelling study (expected drawdown is no more than 3 m).- Conduct routine monitoring at production bores and specific community locations- Apply Best Available Technology (BAT) throughout the design, including extensive water recycling, use of fin fan cooling as an alternative to cooling towers, and heat integration, to significantly reduce overall potential water usage.	21 - Negligible	7 – Unlikely	28 - Low
	Linear infrastructure (e.g. access roads, tracks and utilities corridors) combined with rainfall event(s) results in altered hydrology during rainfall event	Yes	Groundwater and surface water	Potential for crossing drainage structures associated with linear infrastructure to impede or divert natural flow and/or increasing channel flow velocity.	Construction and Operation	Change in hydrological flow regimes/ natural drainage systems and increased risk of flooding during heavy rainfall events that may damage or cause overflow to flood levee surrounding the mine pit. Key changes in Proposed Project include new processing areas and modified levees positions	11 - Moderate	7 – Unlikely	18 - Medium	- Use of buffer zones, sediment fences, and sediment ponds to arrest the transport of water borne sediment from the site. - Stage clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP. - Staging of Construction to occur in the dry season. - Use of soil binding polymers applied to areas left cleared for any period of time. - Provision of suitable outlet scour protection measures as per ESCP. - Maintain natural surface water flows in minor watercourses by the use of floodways at creek crossings. - Adoption of appropriately sized culverts to maintain flows at major creek crossing. - Appropriate consideration of surface water flow in the design and placement of infrastructure. - Develop and implement an Erosion and Sediment Control Plan. - Adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance	16 - Minor	7 – Unlikely	23 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										- Adherence to prescribed maximum operating level and retention freeboard. - Construct to ANCOLD specifications, including liner. - Conduct regular inspections by accredited phosphogypsum stack auditors - Update the Water Management Plan and Closure Plan to reflect the addition of the GSA - Access Road designed for water to flow under during 1 in 5-year flood event. During larger flood event surface water would flood over road. However, road is positioned upstream of flood levee and is therefore unlikely to impact natural water flows.			
2.2 Inland water environmental quality Protect the quality of groundwater and surface water so that environmental values including ecological health, land uses and the welfare and amenity of people are maintained	Chemicals and hazardous materials (e.g., leachate from gypsum waste stack, acid metalliferous and saline drainage) used and stored onsite (Project/Mine Site).	Yes	Groundwater and surface water	Accidental chemical/hazardous material release contaminating surface water or groundwater	Operation and decommissioning	Contamination of the Georgina Basin carbonate aquifer and surrounding environment/ surface water streams	11 - Moderate	5 – Possible	16 - Medium	- Current stack design includes a lined base and runoff collection minimising risk of contamination to the surrounding environment. - Construction design of gypsum stacking facility in adherence to ANCOLD tailings dam specifications. - Update hazardous chemicals and materials storage handling procedures to include leachate management including monitoring of leachate for pH, electrical conductivity, major ions, nitrogen suite, Al, As, B, Cd, Cr, Cu, Pd, Mn, Ni, Se, Br, B, F and P. - Adhere to 0.1 µm filter size. - Ensure future analysis of Cr speciation includes a lower detection limit so the results can be effectively compared to the guidelines (while the previous recommendation of completing Cr speciation has been adopted, the detection limit of 0.025 mg/l for Cr VI is higher than the guideline of 0.001 mg/L).	16 - Minor	9 – Rare	25 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
3. Sea													
3.2 Marine environmental quality Protect the quality and productivity of water, sediment, and biota so that environmental values are maintained.	Chemicals and hazardous materials (e.g., leachate from gypsum waste stack, acid metalliferous and saline drainage) used and stored onsite (Darwin Port).	Yes	Marine water quality	Accidental chemical/hazardous material release contaminating marine water from materials handling facilities at Port	Operation	Contamination to port marine waters from accidental releases / materials handling at Darwin Port	11 - Moderate	5 – Possible	16 - Medium	- Ensure adequate upgrade / modification of storage and handling facilities (and associated infrastructure) at the Darwin Port for the temporary under-cover storage of export fertilisers and imported sulphur. Port of Darwin Facilities will comply with the Port Authority Environmental conditions.	16 - Minor	9 – Rare	25 - Low
4. Air													
4.1 Air quality Protect the air quality and minimise emissions and their impact so that environmental values are maintained.	Proposed Project (SAP, PAP, AP, GSA, GP)	Yes	Air quality	Combustion generating sources in the mining and processing areas.	Operation	Emission of fine particles and pollutants from fuel combustion, including PM2.5, SOx, NOx, CO. Dispersion resulting in reduced air quality at nearby sensitive receptors (< 5 km) with impacts to human health (i.e., Accommodation Village).	16 - Minor	7 – Unlikely	23 - Low	- A Dust Management Plan (DMP) will be updated in order to avoid, minimise, and control impacts on air quality, particularly PM10 (considered the critical pollutant for sensitive receptors based on updated air quality modelling) near the Accommodation Village (new mine camp). - Establish monitoring site at the new mine camp to audit the dust management plan. This would include PM10 in-air concentration and a dust deposition gauge (as part of wider network) to inform operations (e.g., reducing site activity or significantly increasing the intensity of dust controls (such as water sprays or chemical dust suppressants on major haul road links) - The Air Quality Management Plan will be updated to meet the requirements of the Proposed Project to cover construction and operating phases incorporating.	21 - Negligible	7 – Unlikely	28 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										• Air quality management practices • Emission control measures • Air quality monitoring strategies • Reactive dust monitoring program, as required. -Limit the use of diesel generators where possible in favour of the lower NO2 emission producing natural gas generators. Where diesel generators are installed, low NOx emission generators should be selected.			
4.2 Atmospheric processes Minimise greenhouse gas emissions so as to contribute to the NT governments aspirational target of achieving net zero greenhouse gas emissions by 2050.	Approved Project and Proposed Project	Yes	Atmosphere	Greenhouse gas from plant construction (mainly lost carbon sink from vegetation removal) and operation (ammonia plant) (Scope 1, 2 and 3 emissions).	Construction and Operation	Contributions to greenhouse gas emissions and climate change	11 - Moderate	1 – Almost Certain	12 - High	GGAP in development in collaboration with Northern Territory Government. This will outline the steps Verdant will take to reduce emissions to net zero by 2050.	11 - Moderate	5 – Possible	16 - Medium
5. People													
5.1 Communities and economy Enhance communities and the economy and foster resilience to a changing climate, for the welfare, amenity and benefit of current and future	Groundwater drawdown	Yes	Barkly and Sandover region	Project evokes negative perceptions towards the use of water by mining in an arid area that may have other beneficial users (e.g., stock, domestic bores), including concerns	All	Reduced pastoral productivity and negativity towards the Proposed Project.	16 - Minor	3 – Likely	19 - Medium	- Audit of other users including communities, pastoral requirements. - Updated water abstraction management plan. - Modelling for the Life of Mine, including recovery recharge time post mine. - Adherence to water license requirements - Any new bores required will be drilled by a licensed driller under relevant legislation (e.g., Water Act). - Verdant would assist in extending community bores	16 - Minor	5 – Possible	21 - Medium

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
generations of Territorians				about cultural and aesthetic values of water.						should significant drawdown occur. - Community and stakeholder engagement plan to manage key messaging around water use			
	Transport	Yes	Roads	Public road damage due to increased heavy vehicle use for project and additional traffic generated by the Proposed Project potentially leading to a reduction in operating performance on the road network	All	Acceleration of wear and tear on road pavement due to project vehicles causes routine maintenance to be brought forward (i.e. shortening of design life)Economic and safety reduction as a result of congestion	16 - Minor	5 – Possible	21 - Medium	- Monitor road pavement condition throughout life of project and repair as needed (to condition as agreed with road authority) - Routine Road maintenance, - Clear signage - Active escorts of loads - Proactive communications - Seek Federal/State funding for sealing of key access roads-Ensure additional measures, based on updated TIA, are implemented: • Assistance crews / traffic management crews may be required to drive ahead of oversized vehicles during deliveries. The assistance crews will assist by providing warning of large vehicles ahead and holding traffic where required. • Traffic controllers will be present as required to hold up any traffic where large heavy vehicles are required to occupy more than one traffic lane, drive over the road centre line or turn across oncoming traffic. • Internal roads will be constructed and marked early on, to prevent construction vehicles driving across pedestrian areas. • Installation of truck warning signage along the unsealed roads which make up the main delivery routes to increase awareness of the increased truck volumes and the presence of heavy vehicles • All loading and unloading of materials will be limited to	21 - Negligible	5 – Possible	26 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										specific loading areas within the site. No loading or unloading is to occur on public roads.			
	Businesses	Yes	Businesses	Loss of experienced staff from other employers to the Proposed Project and difficulty in backfilling positions.	All	Loss of productivity for some businesses	11 - Moderate	5 – Possible	16 - Medium	- Ensure consultation with regional stakeholders and potential proponents in the region. - Ensure collaboration with key government agencies and stakeholders to manage the attraction and retention of skilled workforce to backfill any positions created.	16 - Minor	7 – Unlikely	23 - Low
5.2 Culture and heritage Protect sacred sites, culture and heritage.	Proposed Project		Cultural heritage	Site establishment (including vegetation clearing) results in physical disturbance of sites / objects of heritage significance, heritage items or places and/or sacred sites during construction of the Project	Construction	Damage, destruction or removal of heritage items or sacred sites. Non compliance of legislative requirements.	6 - Major	7 – Unlikely	13 - Medium	- The Cultural Heritage Management Plan will be updated as necessary for the Proposed Project, including: • Buffer distances and / or fencing surrounding identified archaeological sites and/or sacred sites • Appropriate signage. • Pre-clearing / disturbance visual investigations. • Procedures to avoid significant sites or areas. • Procedures to protect key sites. • Procedure to manage discovery of unexpected surface or sub-surface items. • Research plan for an appropriate recording and salvage program if requested • Consultation and engagement with Traditional Owners and custodians - AAPA Clearance certificate and CLC clearance certificates will be sourced. Additional controls would be implemented as per the Indigenous Land Use Agreement. - Approval to Carry Out Work on Heritage Place or Object will be sourced from NT Heritage Branch prior to construction.	16 - Minor	7 – Unlikely	23 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										There are two identified exclusion sites in the mineral lease, one in proximity to the mine site location. There are other scattered sites around the transport corridor. There are no soaks near the project footprint. There is no change with the Proposed Project.			
5.3 Human health Protect the health of the Northern Territory population.	Physical and chemical hazards from new operational plants (GP, SAP, AP, PAP, Mining and Dry Beneficiation)	Yes	Human Health and safety	Project personnel exposed to increased silicosis, carcinogenic material, skin irritation and burns, SO2 inhalation, high pressure and temperature releases, hot slurry, fire and explosion, etc.)	Operation	Decline in health and wellbeing of site personnel	6 - Major	9 – Rare	15 - Medium	-The hazards associated with the Proposed Project are well understood, and there are appropriate actions and processes in place to ensure they will be fully addressed and managed as part of the MHF licencing process. -All HazID's were formally recorded with actions either, closed out through changes during the Definitive Feasibility Phase (DFS), assigned to future engineering phases or assigned a management system mitigation, as appropriate. - Perform Hazard Operability reviews (HazOP's) at frozen design stage. -Ensure that any significant HazOP type issues associated with the process plants are inherently covered in the design. - Ensure all measures from Approved Project are implemented as part of Proposed Project (i.e., measures associated with unauthorised site access, security breach, bushfire, manual handling injuries, PPE,	16 - Minor	9 – Rare	25 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										vehicle and equipment design specs, mine design, etc.) .			
	Noise & vibration	Yes	Human Health and safety	Project personnel exposed to increased noise levels during site-based operations (infrastructure, mine operations, etc)	Operation	Consequences of cumulative noise exposure will be an increased risk of industrial noise induced hearing loss (NIHL).	11 - Moderate	7 – Unlikely	18 - Medium	- Operational work safety procedures in the workplace would be developed that comply if WHS regulations on noise, including the following: • Equipment design specifications include noise limits and associated acoustic attenuation requirements etc. • Sealed mobile equipment cabs with noise suppression • Preventative maintenance program for cabins (seals, pressure, noise level test) • Hearing protection • Hearing protection training • Signage to indicate areas where hearing protection is required • Mobile and fixed plant inspection and maintenance program • Job rotation • Noise monitoring program • Worker audiometry testing • Site induction coverage	11 - Moderate	9 – Rare	20 - Low
	Noise & vibration	Yes	Human Health and safety	Residential areas and communities exposed (e.g., Accommodation Village) to increased noise levels during operation.	Construction and Operation	Consequences of cumulative noise exposure will be an increased risk of industrial noise induced hearing loss (NIHL).	11 - Moderate	7 – Unlikely	18 - Medium	- Develop and implement construction work and operational procedures (Noise Management Plan (NMP) for NT EPA submission) detailing the allowable hours for construction, details on construction and operation noise and vibration management measures in addition to complaints handling procedures. These measures include: • Where practical, undertake the loudest works during the recommended standard hours • Haul truck movements on exposed haul routes or open ridgelines of the open cut mine which could cause noise extrusion to sensitive receptors should be minimised during the	11 - Moderate	9 – Rare	20 - Low

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
										evening and night. • Broadband reversing alarms (audible movement alarms) should be used for all site equipment, subject to meeting occupational health and safety requirements, and minimise reversing with beepers where practical. • Turn off plant that is not being used and where practical, operate machines at low speed or power and switch off when not being used rather than left idling for prolonged periods. • Examine and implement where feasible and reasonable, the use of silenced equipment and noise shielding around stationary plant (such as generators), subject to manufacturers' design requirements. • All engine covers should be kept closed while equipment is operating. • Ensure plant is regularly maintained and all mobile equipment are selected, where possible, to minimise noise emissions and maintained in good repair. Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made. • Arrange the work site to minimise the use of movement alarms on vehicles and mobile plant.			

NT EPA Environmental Factors and Objectives	Source	Project Change	Receptor	Risk	Phase	Consequence	C	L	Risk Rating	Applied Control measure	C	L	Residual Risk Rating
	Noise & vibration	Yes	Accommodation Village and Public	Aircraft arriving and departing from the airfield.	All	Loss of amenitySleep disturbance impacts	11 - Moderate	5 – Possible	16 - Medium	- Limit arrivals and departures to less sensitive time periods during operation of the airfield to minimise potential aircraft noise impacts. - Schedule rostering of early arrivals/departures and late afternoon arrivals/departures so as to ensure sleeping times are not adversely impacted. - Aircraft type will change from Construction to permanent Operations when the manning requirements will be lower. Airfield may be used for community / RFD flights in addition to Proposed Project.	16 - Minor	5 – Possible	21 - Medium
	Aviation		Human Health and safety	Aircraft incident with FIFO from areas beyond road travelling distances (e.g., Mount Isa)	All	Multiple fatalities	6 - Major	9 – Rare	15 - Medium	- Proposed Project shall only use CASA approved air carriers with remote FIFO experience.	6 - Major	9 – Rare	15 - Medium

Appendix G

**Consideration of Principles of
Environment Protection and Management**

In accordance with Part 2 of the EP Act, Principles of Environment Protection and Management are required to be considered within the referral. In addition, under section 43 of the EP Act the general environmental duty must be considered. Based on the details within Section 5, the Proposed Project has considered these principles and duties. A comparison of the principles and duties are provided in Table A 7.

Table A 7 Consideration of Principles of Environmental Management and Protection and General Environmental Duty

Principle or duty	Considered in Proposed Project?	Comment
Decision-making principle 1. <i>Decision-making processes should effectively integrate both long term and short term environmental and equitable considerations.</i> 2. <i>Decision-making processes should provide for community involvement in relation to decisions and actions that affect the community.</i>	Yes	Short-term and long-term environmental risks are considered within this referral. The Proposed Project considers impacts to communities through the social impact assessment in Section 15. On-going stakeholder consultation is being implemented for the Proposed Project.
Precautionary principle 1. <i>If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.</i> 2. <i>Decision-making should be guided by:</i> a. <i>A careful evaluation to avoid serious or irreversible damage to the environment wherever practicable; and</i> b. <i>An assessment of the risk-weighted consequences of various options.</i>	Yes	Verdant have considered environmental impacts and uncertainties in the construction and operation of the Proposed Project. Verdant have implemented control measures which considers a risk weighted approach.
Principle of evidence-based decision-making <i>Decisions should be based on the best available evidence in the circumstances that is relevant and reliable.</i>	Yes	In developing the Proposed Project, an evidence-based approach has been utilised.
Principle of intergenerational and intragenerational equity <i>The present generation should ensure that the health, diversity, and productivity of the environment is maintained or enhanced for the benefit of present and future generations.</i>	Yes	Verdant have considered this principle in the Proposed Project.
Principle of sustainable use <i>Natural resources should be used in a manner that is sustainable, prudent, rational, wise, and appropriate.</i>	Yes	Verdant have designed the Proposed Project to reduce natural resource use. As detailed in Section 6.1, plant design has allowed for a water use reduction of approximately 5 GLpa, when compared to alternative technologies. This allows for more sustainable use of groundwater to be extracted. In addition, multiple energy efficiency considerations, as detailed in Section 6.2, has led to reduce natural gas consumption. Verdant are committed to implementing a greenhouse gas abatement plan to reduce emissions to net zero by 2050. This will require investment in: – Energy efficient plant design: designing processes that recycle heat and steam – Preference to electric equipment. – Progressively deploying levels of solar photovoltaic (PV), wind turbines and battery storage to substitute gas used power generation – Converting 50% of fleet to electric vehicles (EV) by 2040 – Progressively expanding investment in renewable energy (solar PV, wind, battery storage) and

Principle or duty	Considered in Proposed Project?	Comment
		electrolysis and hydrogen storage to substitute natural gas as feed to the ammonia plant up to 10% of H₂ feed to the plant. – Increasing investment in renewables, H₂ electrolysis, H₂ storage beyond 10%. – Installing an air separation unit (ASU), to reduce the natural gas feed to the steam methane reformer (SMR) to combine with 50% green hydrogen (H₂) as feed to ammonia (NH₃) plant. – External 3rd party renewables in the form of green energy or green H₂ may be available should other investments in extensive renewable project be developed.
Principle of conservation of biological diversity and ecological integrity <i>Biological diversity and ecological integrity should be conserved and maintained.</i>	Yes	Verdant have demonstrated the application of this principle through the biodiversity considerations within the Section 12 and the control measures to be implemented as listed in Appendix F.
Principle of improved valuation, pricing, and incentive mechanisms 1. Environmental factors should be included in the valuation of assets and services. 2. Persons who generate pollution and waste should bear the cost of containment, avoidance, and abatement. 3. Users of goods and services should pay prices based on the full life cycle costs of providing the goods and services, including costs relating to the use of natural resources and the ultimate disposal of wastes. 4. Established environmental goals should be pursued in the most cost-effective way by establishing incentive structures, including market mechanisms, which enable persons best placed to maximise benefits or minimise costs to develop solutions and responses to environmental problems.	Yes	Verdant take responsibility for the management of the environment for the Proposed Project, through the proposed control measures and monitoring.
Environmental decision-making hierarchy <i>In making decisions in relation to actions that affect the environment, decision-makers, proponents, and approval holders must apply the following hierarchy of approaches in order of priority:</i> a. ensure that actions are designed to avoid adverse impacts on the environment. b. identify management options to mitigate adverse impacts on the environment to the greatest extent practicable. c. if appropriate, provide for environmental offsets in accordance with this Act for residual adverse impacts on the environment that cannot be avoided or mitigated	Yes	Through the impact and risk assessment process (see Appendix F), Verdant have taken an approach which first considers avoiding adverse impacts and then identifies the management options to mitigate adverse impacts.
Waste management hierarchy <i>Waste should be managed in accordance with the following hierarchy of approaches in order of priority:</i> a. Avoidance of the production of waste. b. Minimisation of the production of waste. c. Re-use of waste.	Yes	Waste hierarchy considered in designs and management. Plant design has allowed for reuse of reject reverse osmosis water from the water treatment plant in processing (reuse). Steam recovery within the plant design for use in energy generation reduces overall energy consumption of the Proposed Project (recovery).

Principle or duty	Considered in Proposed Project?	Comment
d. Recycling of waste. e. Recovery of energy and other resources from waste. f. Treatment of waste to reduce potentially adverse impacts. g. Disposal of waste in an environmentally sound manner.		Dry gypsum stacking has been integrated into Proposed Project design. This is considered of lower environmental risk compared to wet stacking which may impact the environment through generation of leach.
General environment duty		
Have communities that may be affected by the proposed action been provided with information and opportunities for consultation?	Yes	See Section 9, 15 and 16
Has consultation with affected communities, including Aboriginal communities' been undertaken in a culturally appropriate manner?	Yes	See Section 9, 15 and 16
Has community knowledge and understanding (including scientific and traditional knowledge and understanding) of the natural and cultural values of areas that may be impacted by the proposed action been sought and documented?	Yes	See Section 9, 15 and 16
Have Aboriginal values and the rights and interests of Aboriginal communities' been addressed in relation to areas that may be impacted by the proposed action?	Yes	See Section 9, 15 and 16

Appendix H

Gypsum and Waste Rock Geochemical Assessment



Ammaroo Ammonium Phosphate Fertiliser Project

Gypsum Waste Stack Geochemical Assessment

Verdant Minerals Pty Ltd

26 September 2022

➔ **The Power of Commitment**



Our ref: 12571099

26 September 2022

Chris Tziolis
Verdant Minerals Pty Ltd

Ammaroo Ammonium Phosphate Fertiliser Project

Dear Chris

The following letter report summarises the ongoing barrel leachate analysis results for the phosphogypsum sample from April 2021 to January 2022. This report displays overall trends and compares the results to national guidelines to help assess potential risk to the surrounding environment. GHD have provided recommendations for the ongoing monitoring of the phosphogypsum leachate based on the results found herein.

Regards



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Appendices

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1. Introduction

1.1 Overview

Verdant Minerals Pty Ltd (Verdant) is a Darwin-based, developer of Australian fertiliser mineral projects, including the Ammaroo Ammonium Phosphate Fertiliser Project (hereinafter abbreviated to 'Ammaroo Phosphate Project' and referred to as the 'Project'). The Project is situated in the central region of the Northern Territory, located in the western Georgina Basin approximately 220 kilometres (km) southeast of Tennant Creek, 125 km east of Barrow Creek and 270 km northeast of Alice Springs.

In 2018, the Project was subject to and approved under an Environmental Impact Assessment, and comprised the development of the Ammaroo resource, by open-cut mining, crushing, beneficiation and drying to produce a phosphate rock concentrate for transportation via rail to the Darwin Port. The Project planned to export the rock concentrate to international markets as the essential feed stock for the production of fertiliser products. (For the purposes of clarity, the 2018 Project will hereafter be referred to as 'the Approved Project').

Verdant have since proposed to make changes to their project to include the onsite production of monoammonium phosphate (MAP) and diammonium phosphate (DAP). As part of these changes, a gypsum waste stack will be created onsite to store the phosphogypsum waste by-product created in the MAP and DPA production process.

In 2018, as part of the assessment of the risk of acid, saline or metalliferous drainage (collectively referred to as AMD), Verdant established field leachate testing barrels to assess the release of soluble metals, metalloids, and other environmentally significant solutes in their waste rock. These are referred to as barrel leach tests. In 2021, an additional barrel leach test was added to inform the AMD risk of the proposed gypsum waste stack.

Barrel leaching is used to simulate the AMD risk associated with long-term effects of rain percolation through stockpiles of the various materials on site including the presence of soluble potential deleterious elements, which may be mobile through the environment.

1.2 Purpose of this report

This report will describe the results of the phosphogypsum barrel leaches and determine the associated risk to the surrounding environment through comparison to relevant guidelines.

1.3 Scope and limitations

This report: has been prepared by GHD for Verdant Minerals Pty Ltd and may only be used and relied on by Verdant Minerals Pty Ltd for the purpose agreed between GHD and Verdant Minerals Pty Ltd as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Verdant Minerals Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Any reports, drawings, memos, or other deliverables produced by GHD shall be produced in a traditional and generally accepted format. Accessible reports, drawings, memos, or other deliverables can be provided by GHD at an additional cost if necessary.

If the GHD document containing the disclaimer is to be included in another document, the entirety of GHD's report must be used (including the disclaimers contained herein), as opposed to reproductions or inclusions solely of sections of GHD's report.

GHD has prepared this report on the basis of information provided by Verdant Minerals Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Assumptions

GHD have assumed the samples provided by Verdant are representative of the materials as described, the testing was carried out according to the procedure outlined below and that the laboratory analytical methods and results are appropriate for the materials tested.

1.5 Data sources

Results and methodology have been provided by Verdant, including the modified barrel leach testing procedure which was originally created by GHD as a draft for waste rock analysis in 2018. This report is based on laboratory results provided Verdant Minerals Ltd.'s, contracting laboratory and spreadsheets provided by Verdant Minerals Ltd.

2. Methods

2.1 Sampling and analysis

2.1.1 Barrel Leach

The long-term effects of percolation of rainwater through waste rock at the proposed Ammaroo Phosphate Mine has been assessed through barrel leach tests that simulate conditions on the site. The detailed description of this methodology is provided in Appendix B, with a summary found in Ammaroo Phosphate Project, preliminary barrel leach test results (GHD, 2018). A brief outline has been included below for expediency.

The assessment includes the construction of one 100 L barrel with 120 kg of sample in each, which is representative of the phosphogypsum waste stack.

Given the low rainfall on site, it would be impractical to simulate the actual annual rainfall or even the most intense events. Instead, the rainfall is greatly accelerated by the addition of a large quantity of water to each sample each month. Each week the liquid leachate is tested for pH, electrical conductivity (EC) and oxidation/reduction potential (ORP) with a calibrated meter. In addition, after each monthly leachate cycle, a set amount of water is collected from the bottom drain tap and sent to the laboratory for analysis.

The tests are proposed to run for a minimum of 18 months. Blanks from the supplied RO water used for leaching and equipment rinsing, collected from the water transport containers, were analysed to test if contamination was coming from the water or from the equipment.

Analysis performed on the barrel leachate is summarised in Table 1.

Table 1 Summary of analysis

Analysis	PHG45 (filter 0.45 micron)	PHG1 (filter 0.1 micron)
pH and EC	1	1
Carbonate, bicarbonate, hydroxide	1	1
Nitrogen suite, phosphorus suite and fluoride	1	1

Analysis	PHG45 (filter 0.45 micron)	PHG1 (filter 0.1 micron)
Major ions including, Na, Ca, Mg, K, Cl and SO ₄	1	1
Full dissolved metals suite	1	1

2.2 Assessment Criteria

The barrel leachate results are compared to the following guidelines:

- Australian New Zealand Guidelines for Freshwater Aquatic Ecosystems 95% (ANZG, 2018).

Earlier reports have been compared against a range of generic guidelines including:

- ANZECC and ARMCANZ Livestock and Irrigation LTV (ANZECC and ARMCANZ, 2000).
- ADWG Health and Aesthetic (NHMRC and NRMCC, 2011).

These guidelines are included to provide context and do not act as requirement that the gypsum samples must report below, rather they assist in the assessment of potential risks to the surrounding environment.

3. Results

3.1 Leachate

3.1.1 Filter differences

In previous barrel leach experiments on site larger filter size (0.45 µm compared to 0.1 µm) some analytes, notably aluminium, were significantly higher. This was considered to be due to the presence of colloidal clays passing the 0.45 µm filter. For the phosphogypsum samples, both filter sizes were used for each leach and the results compared. Most analytes reported the same or very similar concentrations regardless of which filter was used, the greatest difference was observed in the initial stage of the experiment but reduced as time went on. There were a few samples where the larger filter (0.45 µm) reported noticeably higher concentrations throughout the experiment, including B, Br, Hf, Pd, Se, Ta, Te, W, and Li, these did not make a significant difference to the analytes that exceeded the FAE 95% guidelines. Random spikes were observed in both the 0.45 and 0.1 µm filters across the data set. Cr (VI), spikes that occur in both filters are likely sampling or analysis error as they do not fit the overall trend and are isolated incidences, hence they can be considered outliers and ignored. Spikes and dips that only occur on one filter size and not the other (Co, Hg, Os, and Er) are likely caused by the filter differences but as there are occurrences of this on both filter sizes showing increases and decreases, they do not identify one filter being better than the other for more accurate results.

3.1.2 SAR and general water quality

Sample classification for pH, EC and chloride values against indicative classification values (DME, 1995) are presented below. DME (1995) classification guidelines are reproduced in Table 2 for ease of reference. Where values were reported as less than the laboratory detection limit, a value of 50% of the detection limit was used for statistical analysis purposes.

Table 2 DME (1995) classification guidelines

Test	Very Low	Low	Med.	High	Very High
pH (pH unit)	<4.5	4.5 – 5.5	5.5 – 7.0	7.0 – 9.0	>9.0
EC (us/cm)	<150	150 - 450	450 - 900	900 - 2000	>2000
Chloride (mg/kg)	<100	100 - 300	300 – 600	600 – 2000	>2000

A statistical summary of pH, EC, and chloride values for the 2021 – 2022 inclusive PHG1 and PHG45 samples are shown below in Table 3, with classification against DME (1995) provided using most recent values. Full results are included in Appendix A.

Table 3 Summary of pH, EC and Chloride results

Analyte	Material type	Min	Max	Most Recent	Classification based off most recent.
pH	PHG1	1.9	2.3	2.3	Very Low
	PHG45	1.9	2.3	2.3	Very Low
EC	PHG1	7120	13100	7120	Very High
	PHG45	7120	13100	7120	Very High
Chloride	PHG1	1	38	1	Very Low
	PHG45	1	38	1	Very Low

The pH (Figure 1) is the same across both samples as filter size does not affect acidity. The results show a slight increase in pH across the experiment starting at 1.9 and climbing to 2.3 ten months later. These values are considered highly acidic and should be monitored to determine if they continue to decrease in acidity over time. The pH values reported in the leachate are outside the acceptable range of pH for the ADWG (2011) aesthetic guidelines (6.5 – 8.5) and the ANZECC and ARMCANZ (2000) short- and long-term irrigation values (6 – 8.5). The results also classify as very low on the DME guide.

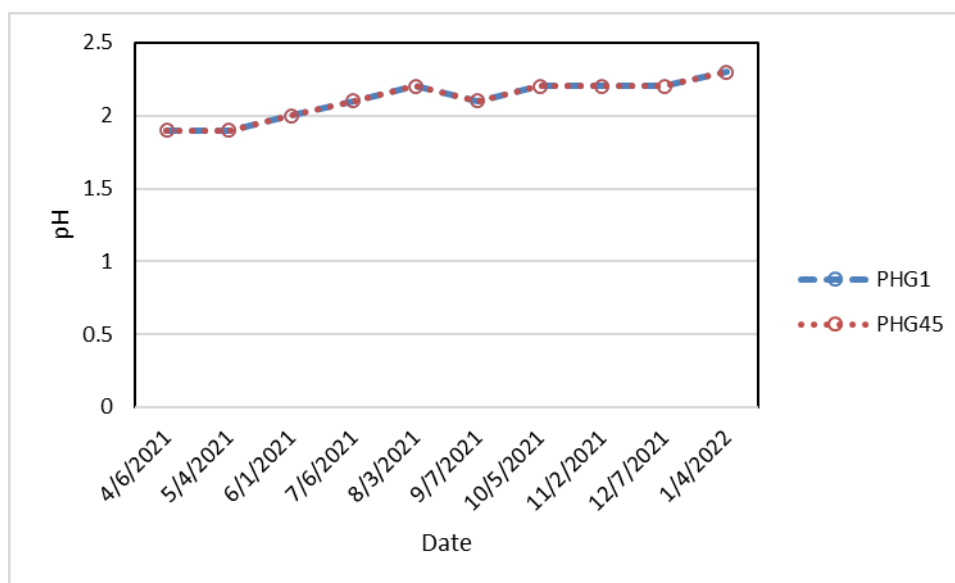


Figure 1 pH vs time for phosphogypsum samples PHG1 and PHG45

The electrical conductivity (EC $\mu\text{S}/\text{cm}$), shows a gradual decrease in concentration over time, suggesting flushing of soluble salts in the entrained liquor. Once again filter size does not affect EC and the results for both samples report identically. Currently the EC values classify as very high on the DME guide and exceed the ADWG aesthetic guideline and the lower limit for ANZECC and ARMCANZ Irrigation. Based on the trends observed in Figure 2 it is likely that with time the EC will continue to decrease until the soluble sulfate salts from the liquor are flushed out and leachate is in equilibrium with gypsum.

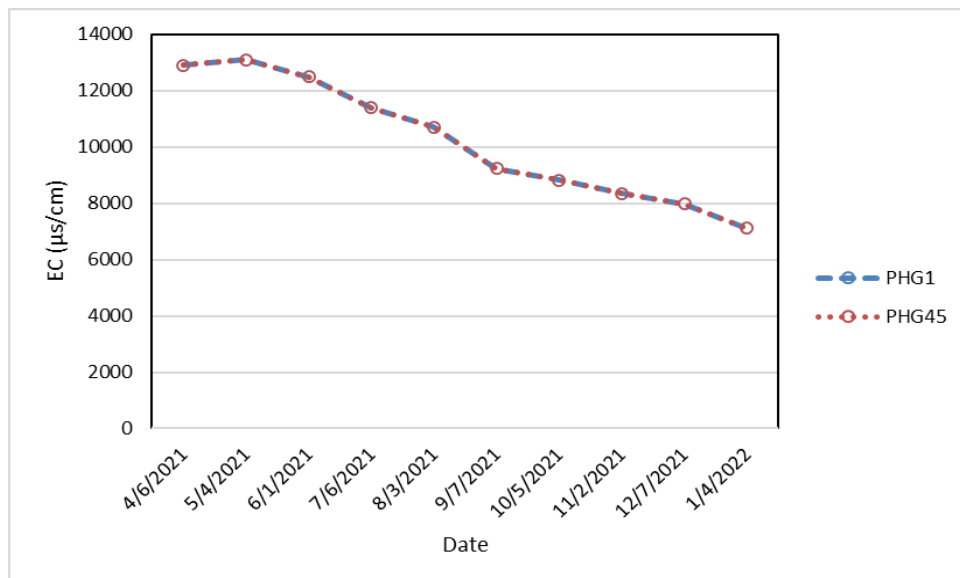


Figure 2 EC vs time for phosphogypsum samples PHG1 and PHG45

The soil dispersion risk classification is calculated by comparing the Sodium Adsorption Ratio (SAR) values to the electrical conductivity (EC). Typically, these values are used to determine the suitability for water for use in agricultural irrigation. While the decant water from the phosphogypsum waste stack is not intended for reuse or environmental release the SAR values can be used to predict stack stability and potential risk to the environment should a release occur. Based on the results shown in Figure 3 the leachate classifies as stable and is unlikely to result in damage to soil structures, with decreasing trends in EC and major ions Na, Ca and Mg ratios remaining similar, a change in classification is unlikely over time.

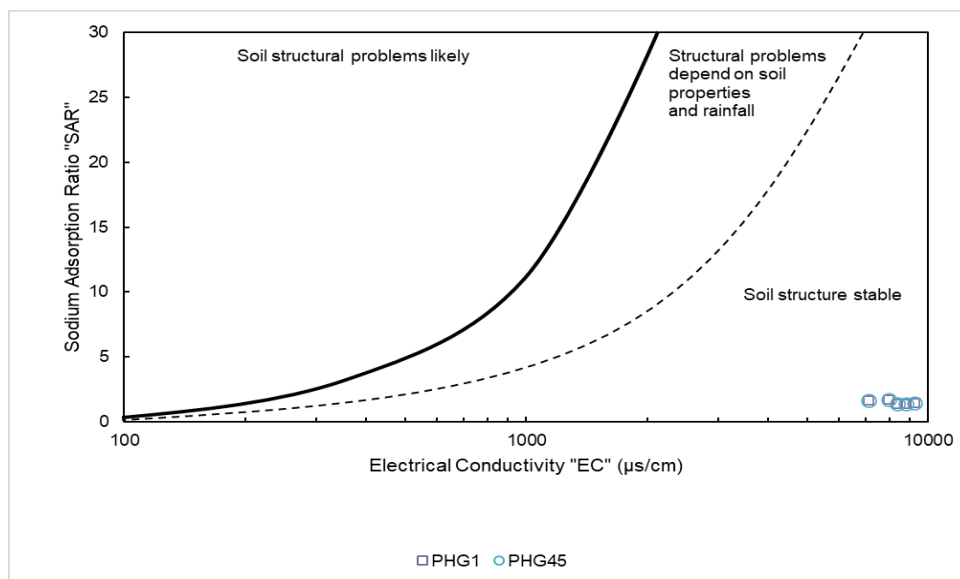


Figure 3 Sodium adsorption ratio (SAR) vs electrical conductivity $\mu\text{S}/\text{cm}$ (EC)

3.1.3 Major ions

Magnesium, potassium, and sodium all gradually decrease by approximately 100 mg/L over the course of the ten-month experiment, calcium is significantly higher in initial concentration and has a more significant drop in concentration over time (Figure 4). Both sulfate and chloride show gradual decrease in concentration over time. Sulfate has had the most significant drop in the last three months (Figure 5). In the last four months chloride has dropped to detection limit (1 mg/l) and now appears to be stable after an initial irregular change in concentration. Both samples have the same concentrations for all ions suggesting that filter size does not play a role in ion concentration.

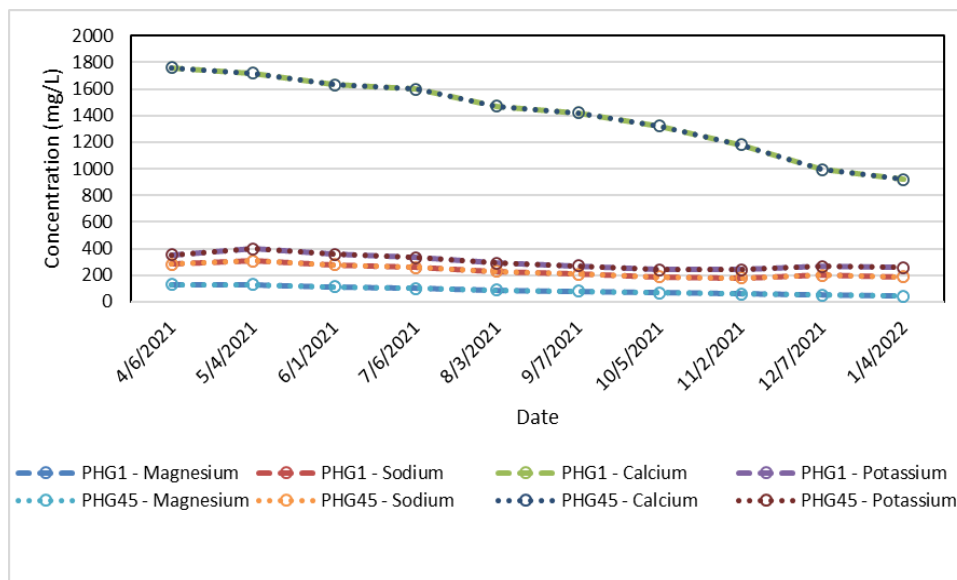


Figure 4 Major cations vs time for phosphogypsum samples PHG1 and PHG45

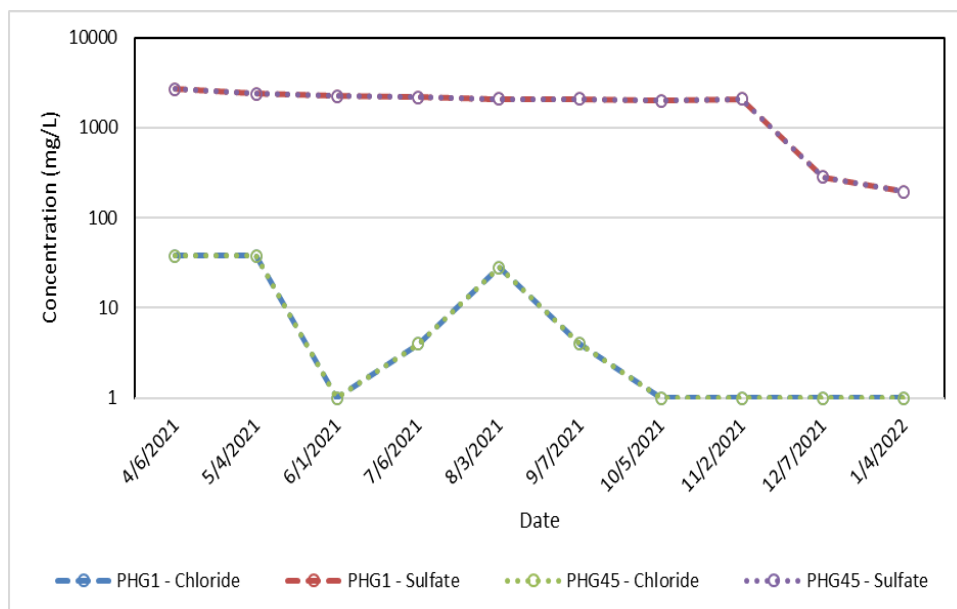


Figure 5 Major anions vs time for phosphogypsum samples PHG1 and PHG45

3.1.4 Metals

There are four main trends observed in the time series data for the barrel leach samples element concentrations.

- Initial first flush, assumed to be soluble chlorides and sulfates, followed by lower values and plateauing data.
- Initial low concentrations followed by a gradual increase in concentration over time.
- Data presenting below detection limit for much of the test.
- Data lacking obvious trends, still showing variability or lack of stability by the end of the test.

The detailed time series graphs of all analytes are included in Appendix A. Table 4 allocates the analytes tested into a generic trend category. Data exhibiting first flush effects followed by plateauing concentrations or gradual decrease present a low risk of sudden change and it is unlikely that ongoing monitoring would be of value. Data that reports below detection limit for much of the test is also at low risk of changing. Any results found to increase in concentration over time or any results that still show high variability at this stage should be closely monitored.

It is likely that the trends can be explained by the following mechanisms:

- Decreasing concentrations associated with flushing of readily soluble salts such as chlorides, carbonates, and monovalent sulfates, from the process liquor, until the equilibrium saturation of less soluble divalent sulfates, such as calcium sulfate (gypsum), dominate the leachate.
- Increasing concentrations are likely due to the increasing solubility/desorption of less soluble elements/minerals as other ion concentrations decrease.
- Data presenting at detection limit is either not present in the material in significant concentrations or is not very soluble.

Table 4 *Observed trends in the analytes*

Observed Trends	PHG1	PHG45
Decreasing concentration or stability	Al, Sb, As, Ba, Be, Bi, B, Cd, Ce, Cs, Cr, Cr III, Co, Cu, Dy, Er, Eu, Gd, Ga, Hf, Ho, Fe, La, Pb, Lu, Mn, Mo, Nd, Ni, Nb, Pd, Pr, Re, Rb, Sm, Sc, Se, Sr, Ta, Tb, Tm, Sn, Th, Ti, Tl, U, V, W, Y, Yb, Zn, Zr, F and Li	Al, Sb, As, Ba, Be, Bi, Cd, Ce, Cs, Cr, Cr III, Co, Cu, Dy, Er, Eu, Gd, Ga, Hf, Ho, Fe, La, Pb, Lu, Mn, Mo, Nd, Ni, Nb, Pd, Pr, Re, Rb, Sm, Sc, Se, Sr, Ta, Tb, Tm, Sn, Th, Ti, Tl, U, V, W, Y, Yb, Zn, Zr, F and Li
Increasing concentration	Br	Br
At or below detection limit	Cr IV, Os, Ag, Au, Hg, In, Pt, Te	Cr IV, Os, Ag, Au, Hg, In, Pt, Te
Results have yet to stabilise		B

Most samples show a decreasing trend in concentration and as such are considered a low risk of changing. Bromine shows an increasing trend in concentration for the last three months of results, and monitoring should continue until this element stabilises. Boron has yet to stabilise in the 0.45 µm filtered sample, it was however stable when measured with the 0.1 µm filter size, this suggests that there is low risk of change in this sample and the instability is a result of the larger filter size.

3.1.5 Guidelines

Elements that had the applicable ANZG (2018) freshwater aquatic ecosystem (95%) guidelines were compared to the barrel leachate results. Relevant elements include Al, As, B, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag and Zn, and total NH₃.

- While aluminium is reported to gradually decrease in concentration throughout the experiment, it exceeds the guideline of 0.055 mg/l from the onset and throughout by greater than 1000 times. This is the case regardless of which filter is used suggesting it is all dissolved Al, which is expected at such a low pH.
- Arsenic reports similarly to aluminium with a decreasing concentration trend over time but exceedances of the guidelines from the onset of the experiment to now. These exceedances are between 10 and 100 times greater.
- Boron exceeds the guidelines for the entirety of the experiment by up to 10 times the guideline value of 0.4 mg/l.

- Cadmium exceeds the guidelines by greater than 1000 times throughout the entire experiment despite decreasing concentrations over time.
- Hexavalent chromium reports at detection limit for the majority of the experiment (0.025 mg/l), detection limit exceeds the guideline of 0.001 mg/L by greater than ten times.
- The chromium (III) fraction appears to make up all of the total chromium in the samples. When compared to a low reliability value of 0.0033 mg/l as an interim working level Cr III exceeds the value by between 100 and 1000 times. Cr III decreases in toxicity with increasing hardness and should be low risk when compared to the calculated hardness values.
- Copper exceeds the guidelines by greater than 1000 times initially and then decreases to between 100 and 1000 times for the remainder of the experiment.
- Lead is missing values for the months of September to December 2021, but all other values report above the guidelines by greater than 1000 times.
- Manganese decreases over time but still exceeds guideline of 1.9 mg/l by between 10 and 100 times.
- Nickel decreases from exceeding the guideline of 0.011 mg/l by between 100 and 1000 times to between 10 and 100 times by the fifth month of the experiment.
- Selenium exceeds the guideline of 0.011 mg/l by up to ten times and is consistently decreasing in concentration over time.
- Zinc initially exceeds the guideline of 0.008 mg/l for the first four months by greater than 1000 times but decreases in concentration to between 100 and 1000 times by the fifth month.
- Ammonia concentrations exceed the guidelines for the duration of the experiment by up to ten times.

There appears to be a sampling or analysis error in August 2021, as several analytes report either lower or higher concentrations than the general trend. These values have been ignored when reporting exceedances and trends. The main metals of concern are, therefore, Al, Cd, Cu, Pb and Zn which exceed the guidelines by greater than 1000 times for some or all of the experiment.

Though the main guidelines compared to results are the ANZG FAE 95% guidelines, these do not have values for some of the analytes assessed. In particular, fluoride and phosphate report at significantly elevated concentrations when compared to ANZECC and ARMCANZ irrigation and livestock guidelines and the ADWG for health and aesthetics (F = up to 4 mg/l for the highest guideline compared to 996 mg/l for the most recent sample concentration and P = up to 0.8 mg/l for short term irrigation use compared to the most recent sample concentration of 1770 mg/l).

3.2 Data Quality

Contamination imparted from sampling transport containers and reagent water was discussed in the initial report for the barrel leach sample and can be found in Ammaroo Phosphate Project, preliminary barrel leach test results (GHD, 2018). It is partially included below for convenience:

“The reagent water and sample transport containers (e.g., drinking water grade blue and green HDPE bottles) and the rinse water from the apparatus (green HDPE drums) showed levels of Zn, Cu and Sb above guideline values, with Zn and Cu exceeding FAE 95% values and Sb exceeding ADWG health guidelines... The blue plastic container exceeded FAE 95% guidelines for Cu and the green plastic container and the rinse water exceeded the guidelines for Zn and Sb. Therefore, high levels of Cu, Zn and Sb in the samples could be partially due to the high levels in the transport containers. The blue and green plastic sample containers and the rinse water reported below all guidelines for all other elements.”

This contamination was considered when reviewing the concentration of Cu, Zn and Sb in the samples across the test.

3.3 Prayon technologies Geochemical assessment

Prayon Technologies analysed the phosphogypsum waste in 2014, 2021, and 2022. Analysis performed on the pilot gypsum waste in 2021 and 2022 is summarised in Table 5 and Table 6.

Table 5 Summary of Prayon gypsum analysis in 2021

Analyte (wt%)	Overall Run
Insol. P ₂ O ₅	0.691
C.I. P ₂ O ₅	0.204
SO ₃	40.2
CaO	29.33
Fe ₂ O ₃	0.083
Al ₂ O ₃	0.085
MgO	0.007
Fe ₂ O ₃	0.237
Na ₂ O	0.038
K ₂ O	0.026
WS. P ₂ O ₅ (g/L)	0.255

Table 6 Summary of Prayon analysis in 2022

Elements (w/w%)	Weak acid	Calcium sulfate dihydrate
Humidity (wet basis)	na	23
Crystal water	na	15.35
P ₂ O ₅	26	1.28
CaO	0.4	26.3
SO ₃	1.9	35.4
F	0.7	0.11 (PRAYON)
K ₂ O	na	0.22 (PRAYON)
Na ₂ O	na	0.04 (PRAYON)
SiO ₂	na	18.7 (PRAYON)
Al ₂ O ₃	1.73	0.25
Fe ₂ O ₃	0.67	0.2
MgO	0.23	0.04
Minor Element Ratio	0.1	0.345

The results of 2021 and 2022 show that S and Ca are the dominant components reporting as SO₃ and CaO, followed by Si as SiO₂.

4. Conclusions and recommendations

The results of the barrel leach tests indicate that some of the analytes (listed in Table 4) are reporting stable concentrations and are at low risk of sudden changes, based on the trends alone it would be appropriate to cease their ongoing assessment. Additionally, analytes that have consistently reported at below detection limit for most of the test can have their ongoing assessment discontinued. Some of these analytes with decreasing trends still report significantly higher than the ANZG FAE 95% guidelines, the monitoring of these should continue to see if over time they reduce in concentration to report below the guidelines.

Based on the metal concentrations in the leachate, the phosphogypsum waste would pose a risk to the surrounding environment if not properly managed. The current stack design includes a lined base and runoff collection and suggests that there is a low risk of contamination to the surrounding environment.

Recommendations for the phosphogypsum:

- Monitoring of leachate should continue for pH, EC, major ions, nitrogen suite, Al, As, B, Cd, Cr, Cu, Pd, Mn, Ni, Se, Br, B, F and P, all other monitoring can cease.
- Differing filtration sizes can cease as no observably significant difference was found between the two. It is recommended to continue with just the 0.1 µm filter size.
- While the previous recommendation of completing Cr speciation has been adopted the detection limit of 0.025 mg/l for Cr VI is higher than the guideline of 0.001 mg/L. Future analysis should include a lower detection limit so the results can be effectively compared to the guidelines.
- The samples report very low pH values ranging from 1.9 to 2.3, acid base accounting should be performed on the samples to determine the impact risk should environmental contamination occur. The solubility of the metals is also influence by pH, additional works such as LEAF method 1313 could inform if metalliferous drainage risk could be reduced at a more neutral pH thus informing potential treatment plans.

5. References

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Appendices

Appendix A

Figures and Tables

		FIELD PHYSICAL PROPERTIES												CALCULATED INDICES													
Sample ID	Date	pH	EC	Na	K	Ca	Mg	CO3	HCO3	OH	Cl-	SO4	SiO2	SAR	Calc Hardness	Al	Sb	As	Ba	Be	Bi	B	Br	Cd	Ce		
Units	dd/mm/yyyy		uS/cm	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)		
PHG1	Apr-21	1.9	12900	283	354	1760	128	0.5	0.5	0.5	38	2670	930	2	4,921	1030	0.0795	0.615	6.49	0.266	0.0002	0.878	0.133	0.703	1.35		
PHG1	May-21	1.9	13100	307	398	1720	130	0.5	0.5	0.5	38	2390	1020	2	4,830	1160	0.1	0.561	6.23	0.241	0.0003	0.778	0.119	0.83	1.36		
PHG1	Jun-21	2	12500	280	358	1630	113	0.5	0.5	0.5	1	2260	905	2	4,535	1060	0.0885	0.522	5.24	0.191	0.0001	0.781	0.115	0.738	1.27		
PHG1	Jul-21	2.1	11400	259	333	1600	102	0.5	0.5	0.5	3.95	2180	801	2	4,415	966	0.0835	0.45	4.94	0.155	0.0001	0.509	0.079	0.682	1.15		
PHG1	Aug-21	2.2	10700	227	291	1470	86.2	0.5	0.5	0.5	28	2070	677	2	4,025	871	0.072	0.359	4.23	0.089	0.0001	0.786	0.083	0.573	1.04		
PHG1	Sep-21	2.1	9240	209	270	1420	77.6	0.5	0.5	0.5	4	2070	585	1	3,865	809	0.0655	0.327	3.85	0.111	0.0001	0.41	0.02	0.516	0.831		
PHG1	Oct-21	2.2	8820	188	242	1320	67	0.5	0.5	0.5	1	2000	492	1	3,572	715	0.058	0.267	3.59	0.099	0.0002	0.751	0.102	0.465	0.693		
PHG1	Nov-21	2.2	8360	179	239	1180	56.7	0.5	0.5	0.5	1	2080	384	1	3,180	627	0.0535	0.225	4.03	0.096	5E-05	0.715	0.475	0.462	0.267		
PHG1	Dec-21	2.2	7,980	199	267	992	51	0.5	0.5	1	1	281	2140	2	2,685	580	0.055	0.185	0.691	0.061	5E-05	0.60	0.44	0.459	0.0378		
PHG1	Jan-22	2.3	7,120	185	259	920	43	0.5	0.5	1	1	196	2020	2	2,474	521	0.047	0.170	0.514	0.0515	5E-05	0.61	0.54	0.42	0.0327		
PHG45	Apr-21	1.9	12,900	283	354	1,760	128	0.5	0.5	1	38	2,670	930	2	4,921	1010	0.082	0.618	6.64	0.263	0.0002	0.95	0.13	0.724	1.38		
PHG45	May-21	1.9	13,100	307	398	1,720	130	0.5	0.5	1	38	2,390	1020	2	4,830	1160	0.105	0.580	6.42	0.252	0.0005	0.83	0.14	0.842	1.43		
PHG45	Jun-21	2	12,500	280	358	1,630	113	0.5	0.5	1	1	2,260	905	2	4,535	1050	0.093	0.528	5.53	0.222	0.0001	1.00	0.15	0.749	1.3		
PHG45	Jul-21	2.1	11,400	259	333	1,600	102	0.5	0.5	1	4	2,180	801	2	4,415	970	0.083	0.467	5.02	0.159	0.0001	1.28	0.10	0.688	1.17		
PHG45	Aug-21	2.2	10,700	227	291	1,470	86	0.5	0.5	1	28	2,070	677	2	4,025	890	0.077	0.000	1.37	4.33	0.147	0.00	0.00	0.08	0.582		
PHG45	Sep-21	2.1	9,240	209	270	1,420	78	0.5	0.5	1	4	2,070	585	1	3,865	806	0.065	0.321	3.85	0.113	0.0001	0.71	0.09	0.527	0.8		
PHG45	Oct-21	2.2	8,820	188	242	1,320	67	0.5	0.5	1	1	2,000	492	1	3,572	719	0.059	0.270	3.7	0.103	0.0002	0.84	0.10	0.471	0.695		
PHG45	Nov-21	2.2	8,360	179	239	1,180	57	0.5	0.5	1	1	2,080	384	1	3,180	628	0.054	0.227	4.17	0.0985	0.0001	1.22	0.56	0.469	0.27		
PHG45	Dec-21	2.2	7,980	199	267	992	51	0.5	0.5	1	1	281	2140	2	2,685	583	0.060	0.186	0.704	0.06	0.0001	0.61	0.47	0.498	0.0389		
PHG45	Jan-22	2.3	7,120	185	259	920	43	0.5	0.5	1	1	196	2020	2	2,474	564	0.048	0.172	0.53	0.0615	5E-05	0.66	0.63	0.421	0.0337		

		METALS																						
Sample ID	Date	Cs	Cr Total	Cr III	CrVI	Co	Cu	Dy	Er	Eu	Gd	Ga	Au	Hf	Ho	In	Fe	La	Pb	Lu	Mn	Hg	Mo	Nd
Units	dd/mm/yyyy		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)					(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)		(mg/L)		(mg/L)	(mg/L)	(mg/L)	
PHG1	Apr-21	0.0115	2.69	2.8	0.025	0.585	1.71	0.405	0.443	0.0423	0.331	0.0643	0.0001	0.0178	0.119	0.0003	138	1.12	10.7	0.0659	51	0.0002	0.126	0.635
PHG1	May-21	0.0138	2.49	2.55	0.025	0.579	1.65	0.394	0.428	0.0417	0.314	0.062	0.0001	0.013	0.114	0.0002	98.7	1.09	13.6	0.0667	48	0.0002	0.116	0.639
PHG1	Jun-21	0.0115	2.18	2.25	0.025	0.546	1.58	0.338	0.1	0.0358	0.293	0.0604	0.0012	0.0134	0.1	0.0001	73.4	0.981	13.8	0.0571	41.8	0.0002	0.104	0.593
PHG1	Jul-21	0.0106	1.85	1.85	0.025	0.475	1.36	0.292	0.332	0.0317	0.254	0.0487	0.0005	0.0116	0.0866	0.0001	52.1	0.898	14.9	0.0519	37.9	0.0002	0.082	0.531
PHG1	Aug-21	0.00933	1.47	1.4	0.050	0.377	1.13	0.259	0.284	0.0268	0.221	0.0412	0.0004	0.0105	0.0737	0.0001	39	0.783	13.8	0.0433	32.5	0.0002	0.0805	0.466
PHG1	Sep-21	0.00806	1.34	1.3	0.025	0.336	1	0.207	0.227	0.0216	0.185	0.0309	0.0002	0.0048	0.0611	0.0001	30	0.627		0.0356	28.9	0.0001	0.0685	0.39
PHG1	Oct-21	0.00864	1.09	1.1	0.025	0.283	0.901	0.18	0.192	0.0189	0.141	0.022	0.0001	0.0009	0.0514	0.0002	22.1	0.534		0.0299	24.9	0.0001	0.061	0.334
PHG1	Nov-21	0.00854	0.943	0.9	0.025	0.242	0.778	0.101	0.112	0.01	0.0761	0.0221	0.0001	0.0007	0.0298	0.0001	14.5	0.197		0.018	22.2	0.0001	0.0475	0.143
PHG1	Dec-21	0.00901	0.762	0.025	0.750	0.2090	0.712	0.035	0.045	0.003	0.021	0.017	0.0001	0.001	0.011	0.000	11.100	0.021		0.0080	21.0	0.00005	0.0405	0.0260
PHG1	Jan-22	0.00844	0.599	0.6	0.025	0.1680	0.579	0.027	0.033	0.002	0.015	0.013	0.0001	0.000	0.008	0.000	7.340	0.017	9.38	0.0063	18.7	0.0001	0.0350	0.0232
PHG45	Apr-21	0.0115	2.81	2.8	0.025	0.6130	1.790	0.416	0.456	0.042	0.329	0.071	0.0001	0.047	0.122	0.000	135.000	1.140	10.80	0.0663	52.7	0.0002	0.1330	0.6530
PHG45	May-21	0.0147	2.57	2.55	0.025	0.5970	1.730	0.407	0.451	0.042	0.325	0.068	0.0001	0.041	0.120	0.000	102.000	1.120	13.90	0.0689	47.8	0.0002	0.1250	0.6690
PHG45	Jun-21	0.0116	2.26	2.25	0.025	0.5550	1.590	0.346	0.382	0.036	0.312	0.065	0.0010	0.016	0.100	0.000	74.700	1.010	14.00	0.0575	42.0	0.0002	0.1060	0.6000
PHG45	Jul-21	0.0107	1.94	1.85	0.025	0.4820	1.400	0.297	0.338	0.033	0.267	0.054	0.0008	0.036	0.088	0.000	52.100	0.908	14.80	0.0519	37.6	0.0002	0.0980	0.5420
PHG45	Aug-21	0.0095	1.46	1.4	0.050	1.0600	1.140	0.266	0.296	0.028	0.228	0.041	0.3700	0.037	0.077	0.000	39.500	0.872	14.00	0.0447	32.1	0.00001	0.0845	0.4710
PHG45	Sep-21	0.0081	1.33	1.3	0.025	0.3470	1.050	0.202	0.222	0.022	0.178	0.032	0.0003	0.013	0.060	0.000	30.200	0.630		0.0339	28.9	0.0001	0.0705	0.3720
PHG45	Oct-21	0.0086	1.1	1.1	0.025	0.2950	0.904	0.182	0.197	0.019	0.142	0.023	0.0001	0.002	0.051	0.000	22.400	0.544		0.0302	25.1	0.0001	0.0615	0.3380
PHG45	Nov-21	0.0086	0.952	0.9	0.025	0.2460	0.794	0.103	0.114	0.010	0.076	0.023	0.0001	0.001	0.030	0.000	15.700	0.199		0.0183	22.3	0.0001	0.0495	0.1450
PHG45	Dec-21	0.0095	0.783	0.025	0.750	0.2260	0.769	0.037	0.045	0.003	0.023	0.018	0.0001	0.001	0.011	0.000	11.800	0.021		0.0081	21.0	0.0001	0.0415	0.0305
PHG45	Jan-22	0.0088	0.609	0.6	0.025	0.1720	0.587	0.028	0.034	0.002	0.016	0.014	0.0001	0.001	0.009	0.000	7.340	0.017	9.58	0.0063	20.6	0.0001	0.0355	0.0238

Sample ID	Date	Ni	Nb	Os	Pd	Pr	Re	Rb	Sm	Sc	Se	Ag	Sr	Ta	Te	Tb	Tl	Tm	Sn	Th	Ti	U	
		(mg/L)									(mg/L)	(mg/L)	(mg/L)	(mg/L)				mg/L		(mg/L)	(mg/L)	(mg/L)	mg/L
PHG1	Apr-21	1.77	0.0358	0.001	0.012	0.154	0.0056	0.512	0.159	0.203	0.0166	0.0005	4.51	0.0285	0.001	0.0515	0.0094	0.0675	0.0031	0.143	1.17	3.77	
PHG1	May-21	1.77	0.0164	0.001	0.013	0.158	0.0074	0.557	0.155	0.159	0.0138	0.0005	5.27	0.0195	0.001	0.0496	0.0115	0.0637	0.002	0.087	0.784	4.58	
PHG1	Jun-21	1.67	0.031	0.01	0.011	0.143	0.0067	0.435	0.142	0.134	0.0424	0.0005	4.89	0.0275	0.001	0.0449	0.00975	0.0578	0.001	0.0674	0.956	3.85	
PHG1	Jul-21	1.4	0.0238	0.001	0.0105	0.127	0.0061	0.432	0.126	0.104	0.0218	0.0005	4.65	0.0225	0.001	0.0388	0.00801	0.0478	0.001	0.0483	0.7	3.29	
PHG1	Aug-21	1.13	0.012	0.001	0.009	0.116	0.0055	0.376	0.106	0.094	0.0202	0.0005	4.22	0.02	0.001	0.0338	0.00765	0.0423	0.001	0.0375	0.622	3.1	
PHG1	Sep-21	1	0.0082	0.0005	0.016	0.0941	0.0049	0.361	0.086	0.084	0.0468	0.00025	3.92	0.0135	0.0013	0.0267	0.00771	0.0343	0.0012	0.0268	0.526	2.59	
PHG1	Oct-21	0.874	0.0052	0.0005	0.0071	0.0799	0.0047	0.336	0.0751	0.0525	0.0134	0.00005	3.54	0.0045	0.0011	0.023	0.00703	0.0296	0.0011	0.0203	0.326	2.27	
PHG1	Nov-21	0.731	0.0041	0.0005	0.0072	0.0327	0.0048	0.388	0.0371	0.0375	0.0108	0.00025	3.19	0.0022	0.0005	0.0125	0.00783	0.0171	0.0007	0.0113	0.23	2.08	
PHG1	Dec-21	0.6230	0.0025	0.0005	0.0064	0.0055	0.0043	0.4460	0.0089	0.0250	0.013	0.00025	2.54	0.0017	0.0005	0.0043	0.01	0.01	0.0009	0.0014	0.166	2.130	
PHG1	Jan-22	0.4920	0.0019	0.0005	0.0058	0.0048	0.0043	0.4460	0.0072	0.0180	0.012	0.00025	2.5	0.0023	0.0005	0.0029	0.01	0.01	0.0005	0.0009	0.128	1.950	
PHG45	Apr-21	1.8500	0.0604	0.0010	0.0120	0.1570	0.0062	0.5280	0.1600	0.2190	0.022	0.0005	4.7	0.044	0.001	0.0526	0.01	0.07	0.003	0.15	1.2	3.800	
PHG45	May-21	1.8300	0.0228	0.0005	0.0135	0.1650	0.0073	0.5740	0.1630	0.1600	0.016	0.0005	5.41	0.03	0.002	0.0521	0.01	0.07	0.003	0.0895	0.8	4.760	
PHG45	Jun-21	1.6700	0.0320	0.0005	0.0120	0.1430	0.0068	0.4590	0.1420	0.1430	0.042	0.00025	4.92	0.025	0.003	0.0453	0.01	0.06	0.0005	0.0667	0.96	3.900	
PHG45	Jul-21	1.4500	0.0446	0.0010	0.0110	0.1300	0.0066	0.4380	0.1270	0.1050	0.022	0.0005	4.66	0.0325	0.001	0.0397	0.01	0.05	0.002	0.06	0.74	3.610	
PHG45	Aug-21	1.1400	0.0210	0.0010	0.0090	0.1180	0.0056	0.3750	0.1100	0.1080	0.022	0.00005	4.3	0.035	0.001	0.0345	0.01	0.04	0.002	0.0407	0.64	3.100	
PHG45	Sep-21	1.0400	0.0108	0.0005	0.0160	0.0911	0.0051	0.3630	0.0849	0.0850	0.050	0.00025	4.02	0.0185	0.002	0.0262	0.01	0.03	0.001	0.026	0.54	2.580	
PHG45	Oct-21	0.8790	0.0060	0.0005	0.0075	0.0825	0.0046	0.3330	0.0766	0.0530	0.018	0.00025	3.6	0.007	0.002	0.023	0.01	0.03	0.001	0.0206	0.34	2.290	
PHG45	Nov-21	0.7470	0.0048	0.0005	0.0105	0.0332	0.0052	0.3880	0.0380	0.0375	0.014	0.00025	3.24	0.003	0.0005	0.0126	0.01	0.02	0.0005	0.0115	0.24	2.100	
PHG45	Dec-21	0.6800	0.0030	0.0005	0.0070	0.0058	0.0045	0.4500	0.0093	0.0260	0.014	0.00025	2.58	0.003	0.0005	0.0045	0.01	0.01	0.0005	0.0013	0.18	2.160	
PHG45	Jan-22	0.5090	0.0022	0.0005	0.0060	0.0050	0.0043	0.4650	0.0073	0.0175	0.014	0.00025	2.65	0.003	0.0005	0.003	0.01	0.01	0.0005	0.0009	0.14	1.970	

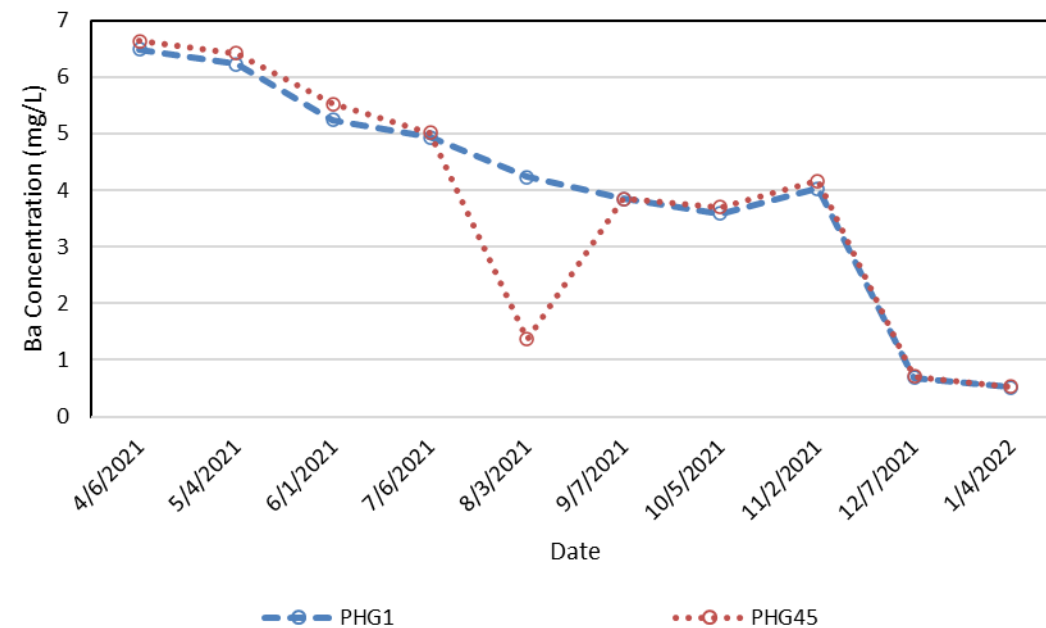
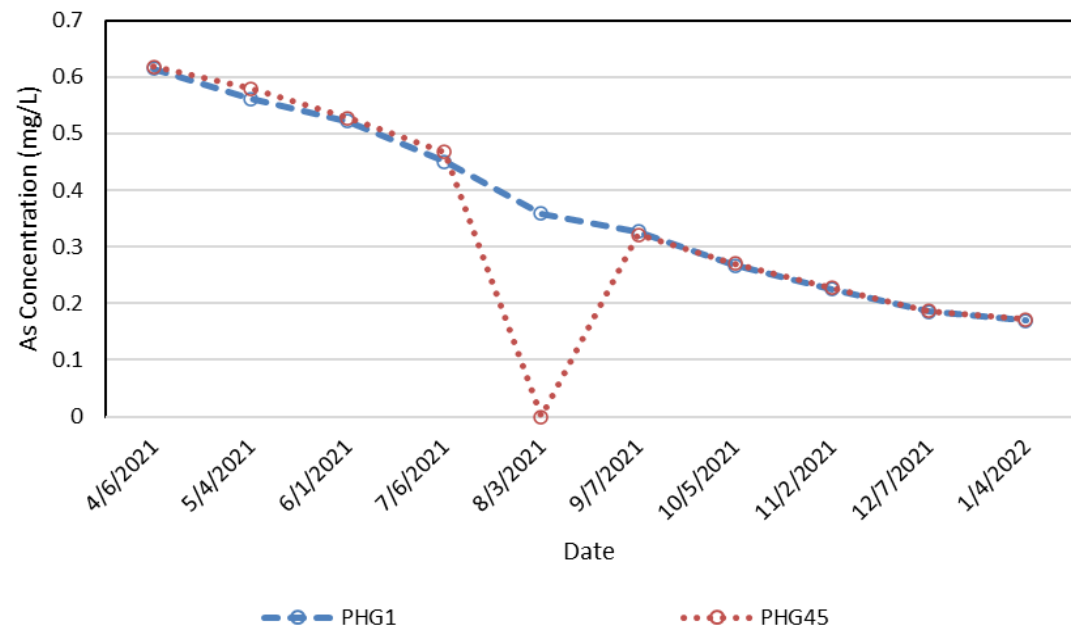
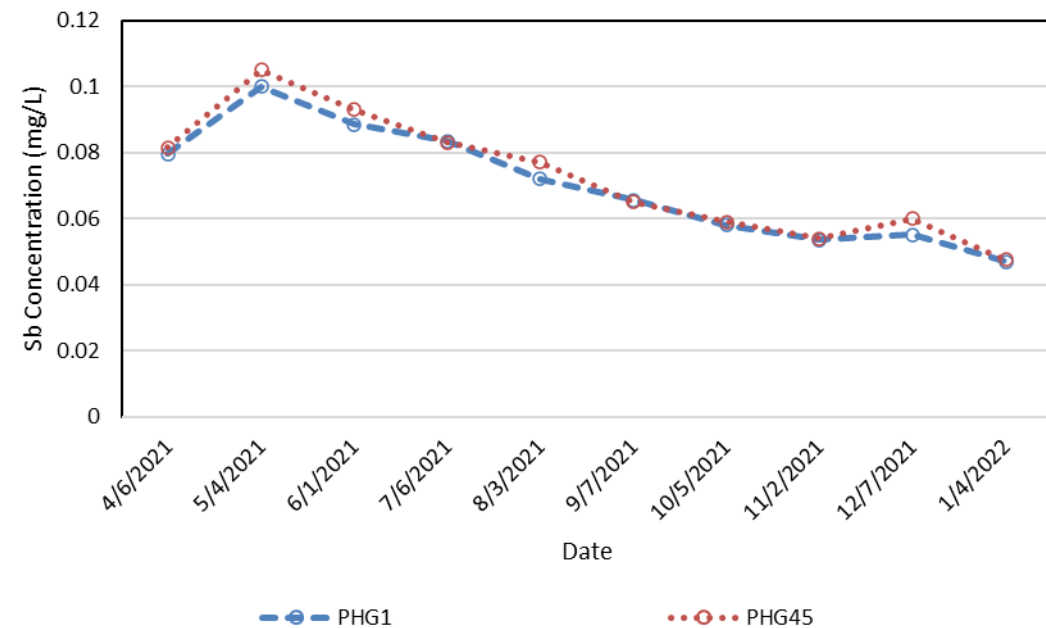
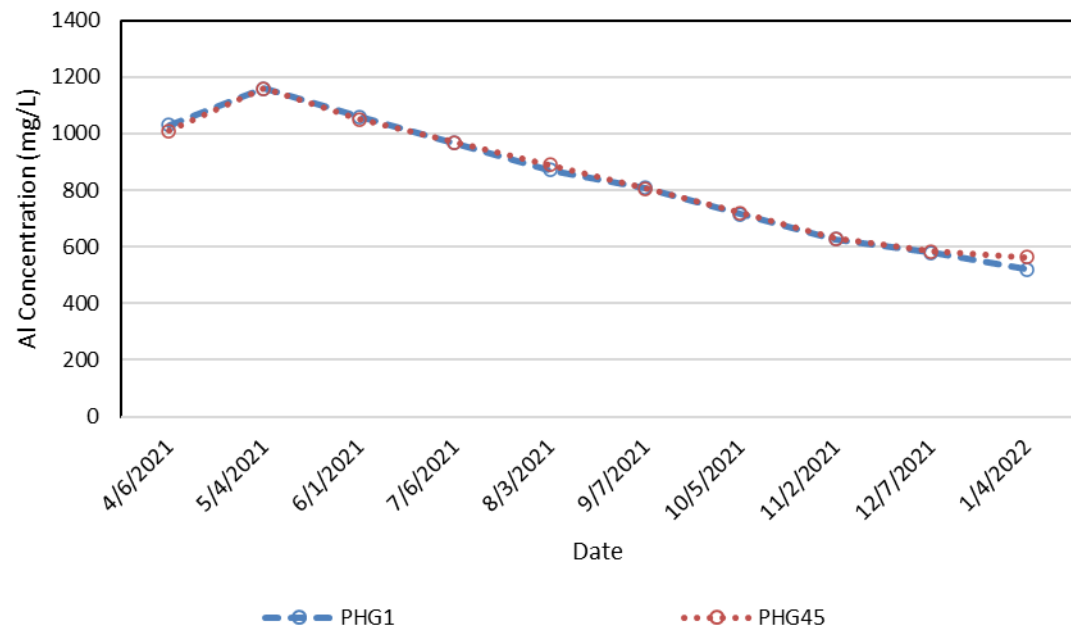
								HARDNESS CORRECTED METALS								NON-METALLIC INORGANICS							
Sample ID	Date	V	W	Y	Yb	Zn	Zr	Cd	Cr	Cu	Pb	Ni	Zn	F	Li	NO ₂ as N	NO ₃ as N	NO _x (NO ₃ + NO ₂) as N	Total NH ₃ as N (@pH 6.0 to 9.0)	Total N		PO4	Total P
Units	dd/mm/yyyy	(mg/L)	(mg/L)			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)
PHG1	Apr-21	3.35	0.0057	6.32	0.414	11	0.431	0.01	0.00	0.02	0.02	0.02	0.14	1930	0.795	0.015	0.17	0.19	4.4	8.03		2900	4350
PHG1	May-21	3.32	0.0053	6.33	0.405	10.8	0.26	0.01	0.00	0.02	0.02	0.02	0.14	4000	0.916	0.015	0.185	0.2	5.17	8.82		4650	4680
PHG1	Jun-21	3.01	0.0049	5.41	0.351	9.91	0.182	0.01	0.00	0.02	0.02	0.02	0.14	3580	0.796	0.015	0.02	0.035	4.36	4.92		5850	5930
PHG1	Jul-21	2.62	0.0056	4.81	0.293	8.47	0.138	0.01	0.00	0.02	0.03	0.02	0.12	2930	0.743	0.01	0.22	0.23	1	4.16		2510	3060
PHG1	Aug-21	2.08	0.007	3.84	0.276	6.96	0.102	0.01	0.00	0.02	0.03	0.02	0.11	2570	0.497	0.03	0.13	0.16	3.5	3.63		3720	3740
PHG1	Sep-21	1.97	0.0042	3.15	0.217	6.06	0.083	0.01	0.00	0.02	0.00	0.02	0.10	2520	0.61	0.0025	0.115	0.115	3.73	3.85		2020	2120
PHG1	Oct-21	1.62	0.0026	2.47	0.184	5.38	0.0615	0.01	0.00	0.02	0.00	0.02	0.09	2270	0.562	0.015	0.1	0.115	2.91	2.98		1900	5860
PHG1	Nov-21	1.38	0.0016	1.06	0.111	4.67	0.0405	0.01	0.00	0.01	0.00	0.01	0.09	1750	0.619	0.015	0.085	0.105	2.92	3.1		723	2380
PHG1	Dec-21	1.15	0.0011	0.112	0.0464	3.59	0.024	0.01	0.02	0.02	0.00	0.01	0.08	1370	0.581	0.003	0.08	0.085	3.03	5.35		1250	1630
PHG1	Jan-22	0.958	0.0012	0.0794	0.0361	3.00	0.013	0.01	0.00	0.01	0.03	0.01	0.07	996	0.568	0.003	0.07	0.075	2.79	4.02		534	1770
PHG45	Apr-21	3.5	0.0275	6.55	0.42	11.50	0.460	0.01	0.00	0.02	0.02	0.02	0.15	1930	0.823	0.015	0.17	0.190	4.40	8.03		2900	4350
PHG45	May-21	3.42	0.0305	6.53	0.422	11.20	0.278	0.01	0.00	0.02	0.02	0.02	0.15	4000	0.947	0.015	0.185	0.200	5.17	8.82		4650	4680
PHG45	Jun-21	3.06	0.029	5.53	0.374	10.00	0.190	0.01	0.00	0.02	0.02	0.02	0.14	3580	0.897	0.015	0.02	0.035	4.36	4.92		5850	5930
PHG45	Jul-21	2.72	0.0225	4.83	0.313	8.71	0.151	0.01	0.00	0.02	0.03	0.02	0.13	2930	0.748	0.010	0.22	0.230	1.00	4.16		2510	3060
PHG45	Aug-21	2.09	0.0265	3.91	0.282	6.95	0.113	0.00	0.00	0.02	0.03	0.02	0.11	2570	0.795	0.030	0.13	0.160	3.50	3.63		3720	3740
PHG45	Sep-21	1.99	0.014	3.14	0.215	6.46	0.083	0.01	0.00	0.02	0.00	0.02	0.10	2520	0.629	0.003	0.115	0.115	3.73	3.85		2020	2120
PHG45	Oct-21	1.63	0.0065	2.51	0.185	5.32	0.063	0.01	0.00	0.02	0.00	0.02	0.09	2270	0.616	0.015	0.1	0.115	2.91	2.98		1900	5860
PHG45	Nov-21	1.39	0.004	1.06	0.112	4.82	0.042	0.01	0.00	0.02	0.00	0.01	0.09	1750	0.725	0.015	0.085	0.105	2.92	3.1		723	2380
PHG45	Dec-21	1.26	0.0025	0.112	0.0473	3.63	0.025	0.01	0.02	0.02	0.00	0.01	0.08	1370	0.592	0.003	0.08	0.085	3.03	5.35		1250	1630
PHG45	Jan-22	0.96	0.003	0.08	0.0369	3.03	0.014	0.01	0.00	0.01	0.04	0.01	0.07	996	0.641	0.003	0.07	0.075	2.79	4.02		534	1770

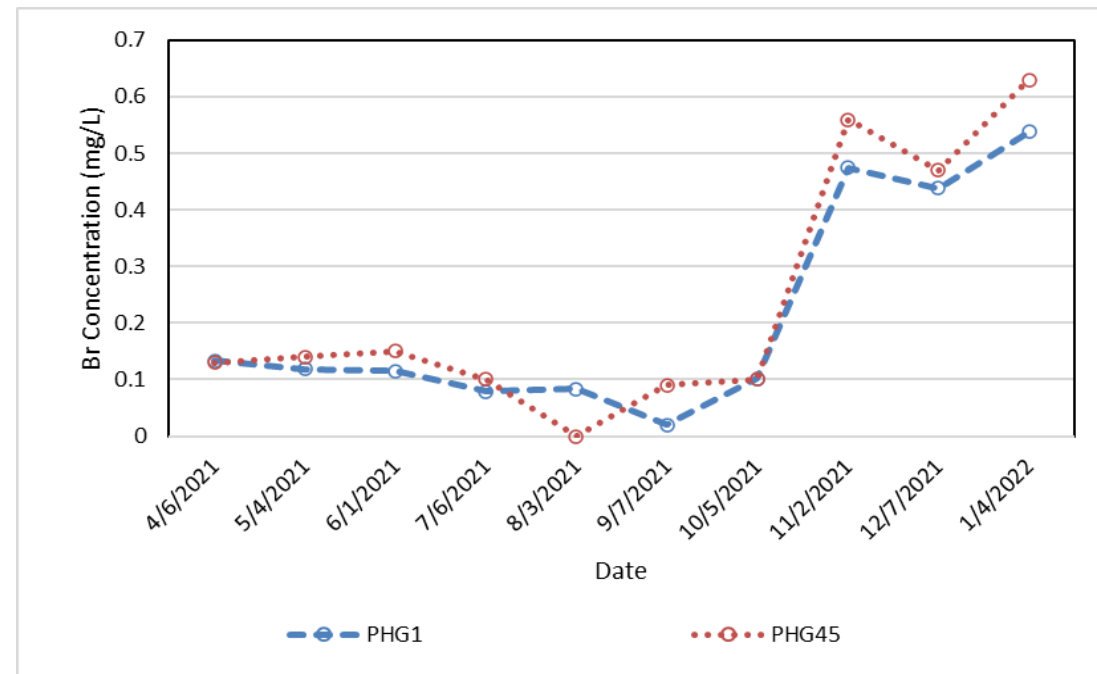
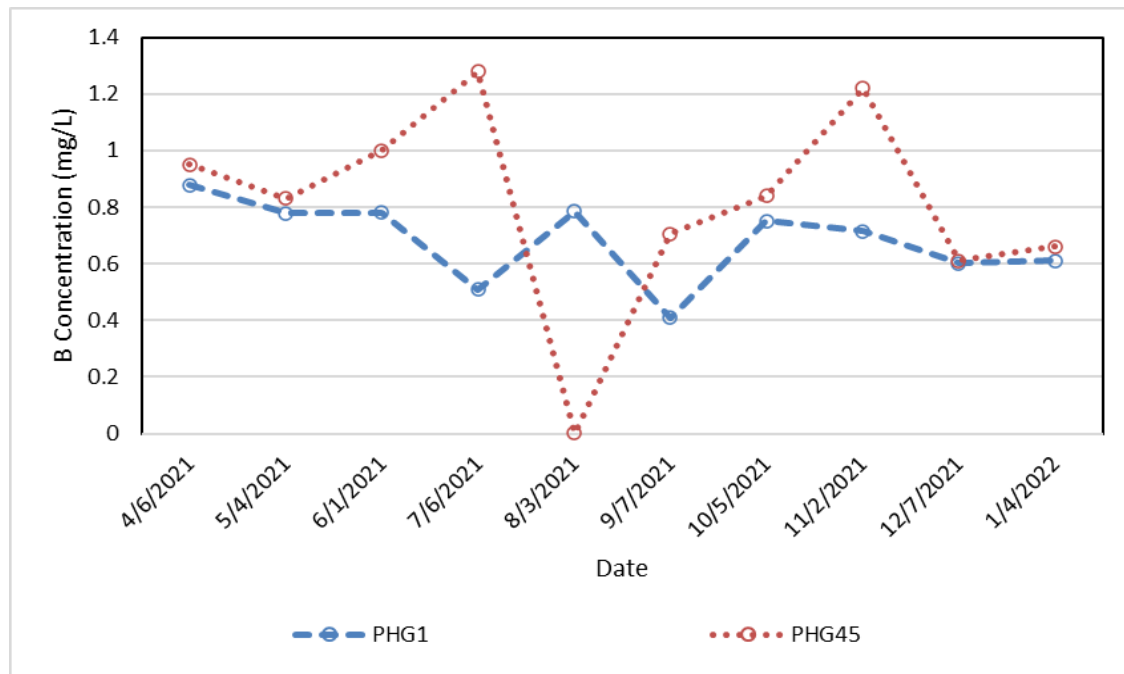
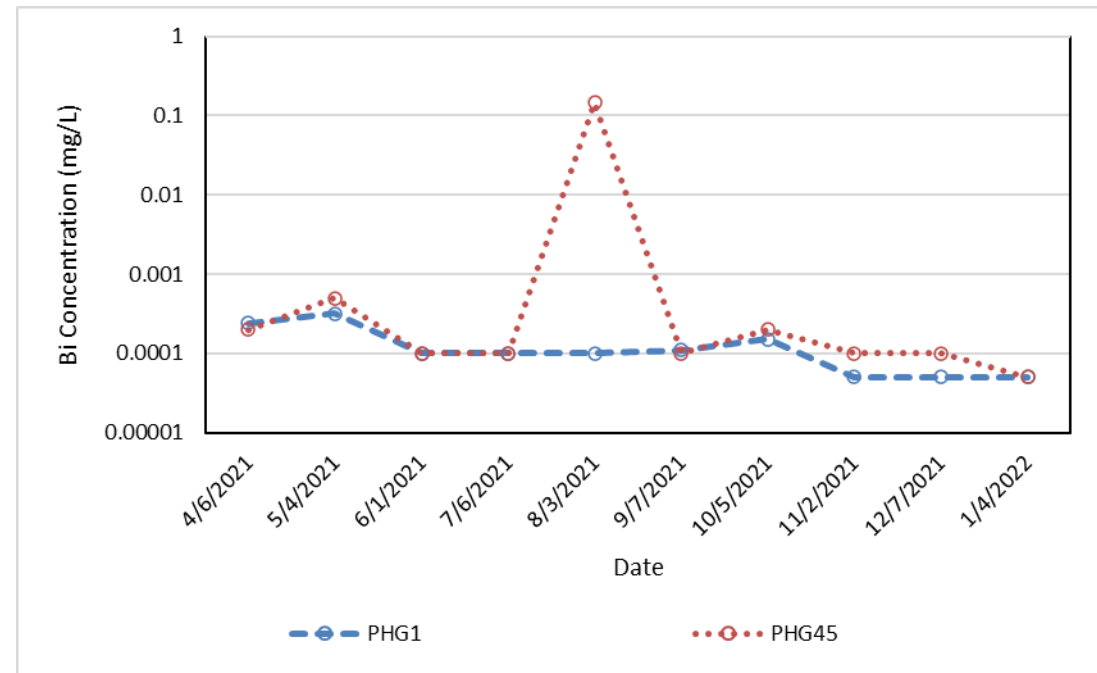
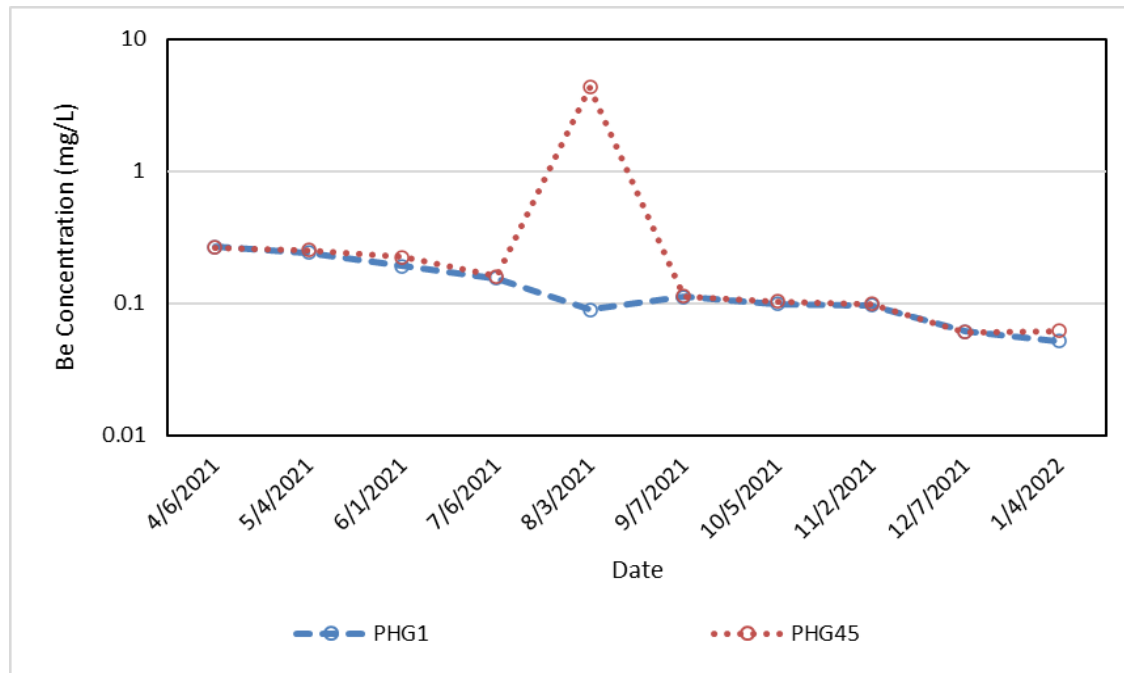
		FIELD PHYSICAL PROPERTIES		METALS														HARDNESS CORRECTED METALS						NON-METALLIC INORGANICS
Sample ID	Date	pH	EC	Al	As	B	Cd	Cr III	CrVI	Cu	Pb	Mn	Ni	Se	Ag	Zn	Cd	Cr	Cu	Pb	Ni	Zn	Total NH ₃ as N (@pH 6.0 to 9.0)	
Units	dd/mm/yyyy		uS/cm	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
ANZAST (2018) FAE 95%		NA	NA	0.055	0.013	0.4	0.0002	0.0033	0.001	0.001	0.003	1.9	0.011	0.011	0.00005	0.008	0.0002	0.001	0.001	0.003	0.011	0.008	0.9	

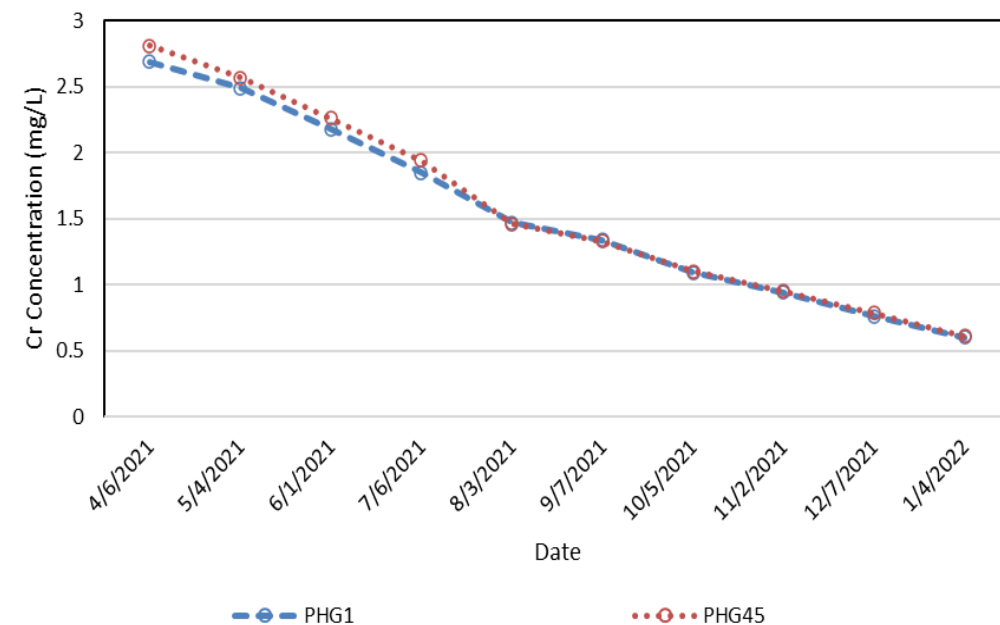
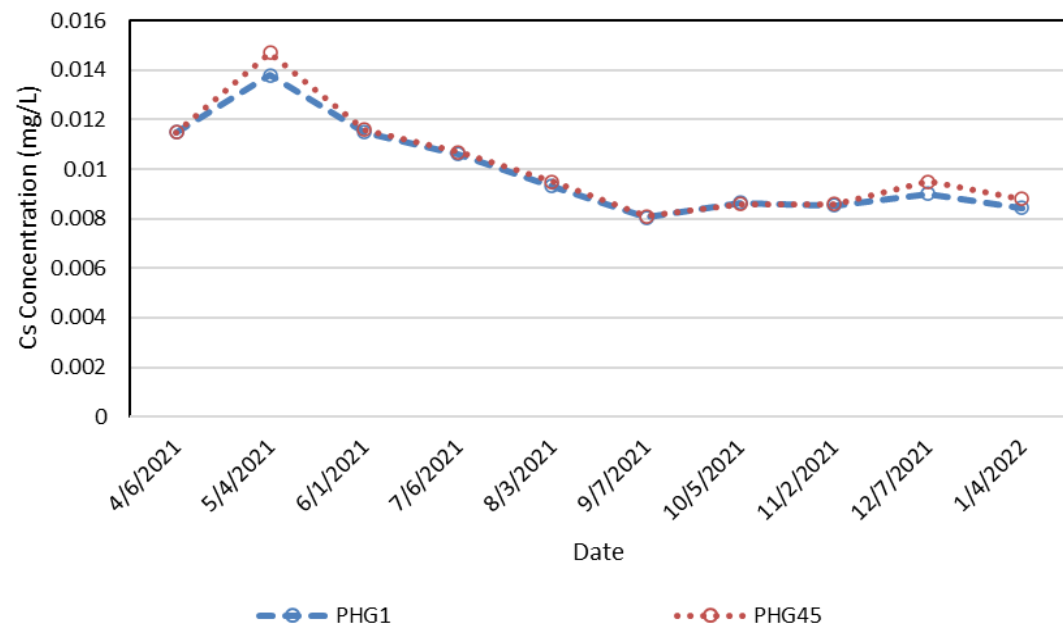
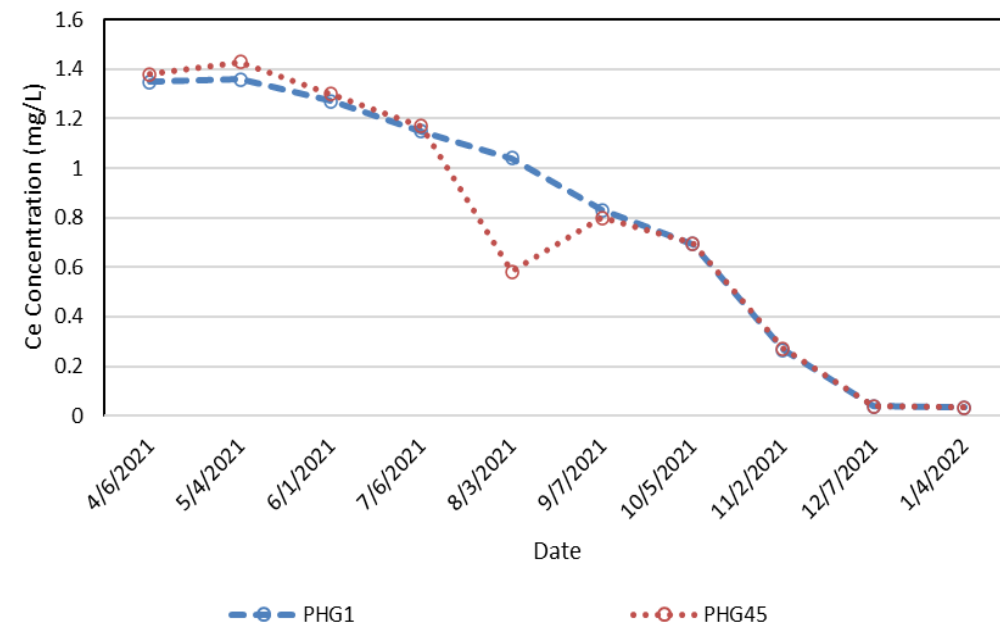
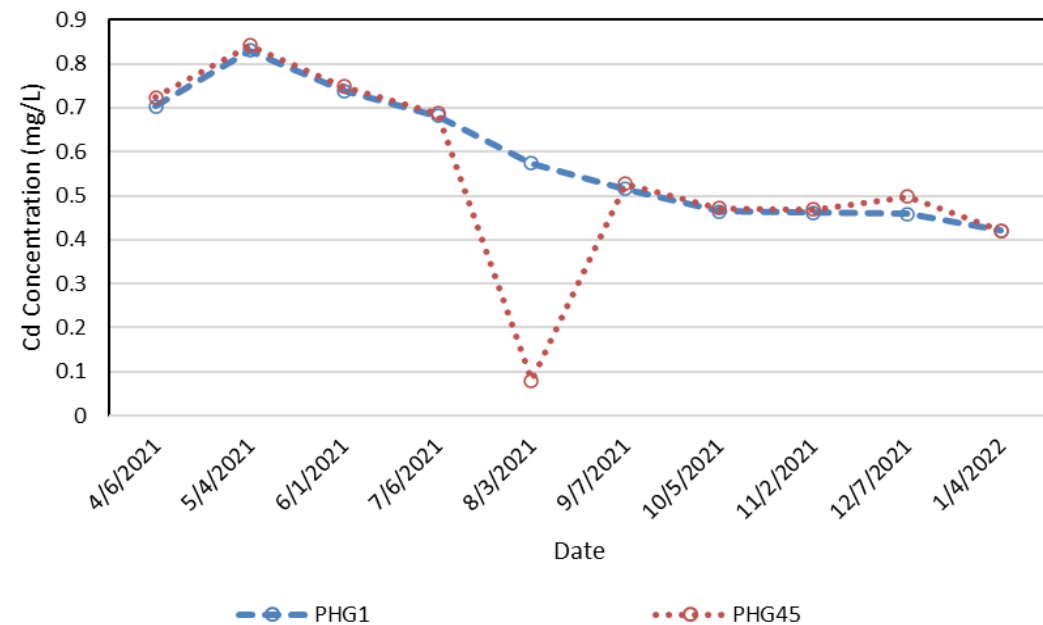
PHG1	Apr-21	1.9	12900	1030	0.615	0.878	0.703	2.8	0.025	1.71	10.7	51	1.77	0.0166	0.0005	11	0.01	0.0004	0.02	0.02	0.02	0.14	4.4
PHG1	May-21	1.9	13100	1160	0.561	0.778	0.83	2.55	0.025	1.65	13.6	48	1.77	0.0138	0.0005	10.8	0.01	0.0004	0.02	0.02	0.02	0.14	5.17
PHG1	Jun-21	2	12500	1060	0.522	0.781	0.738	2.25	0.025	1.58	13.8	41.8	1.67	0.0424	0.0005	9.91	0.01	0.0004	0.02	0.02	0.02	0.14	4.36
PHG1	Jul-21	2.1	11400	966	0.45	0.509	0.682	1.85	0.025	1.36	14.9	37.9	1.4	0.0218	0.0005	8.47	0.01	0.0004	0.02	0.03	0.02	0.12	1
PHG1	Aug-21	2.2	10700	871	0.359	0.786	0.573	1.4	0.050	1.13	13.8	32.5	1.13	0.0202	0.0005	6.96	0.01	0.0009	0.02	0.03	0.02	0.11	3.5
PHG1	Sep-21	2.1	9240	809	0.327	0.41	0.516	1.3	0.025	1		28.9	1	0.0468	0.00025	6.06	0.01	0.0005	0.02	0	0.02	0.10	3.73
PHG1	Oct-21	2.2	8820	715	0.267	0.751	0.465	1.1	0.025	0.901		24.9	0.874	0.0134	0.00005	5.38	0.01	0.0005	0.02	0	0.02	0.09	2.91
PHG1	Nov-21	2.2	8360	627	0.225	0.715	0.462	0.9	0.025	0.778		22.2	0.731	0.0108	0.00025	4.67	0.01	0.0005	0.01	0	0.01	0.09	2.92
PHG1	Dec-21	2.2	7,980	580	0.185	0.60	0.459	0.025	0.750	0.712		21.0	0.6230	0.013	0.00025	3.59	0.01	0.0188	0.02	0	0.01	0.08	3.03
PHG1	Jan-22	2.3	7,120	521	0.170	0.61	0.42	0.6	0.025	0.579	9.38	18.7	0.4920	0.012	0.00025	3.00	0.01	0.0007	0.01	0.03	0.01	0.07	2.79

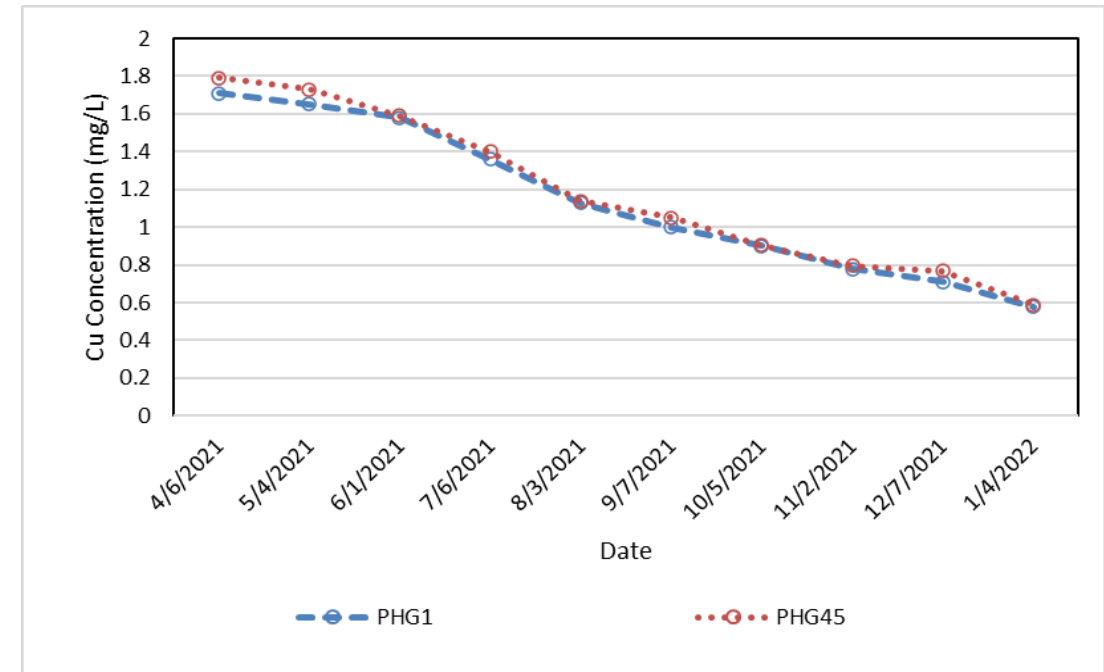
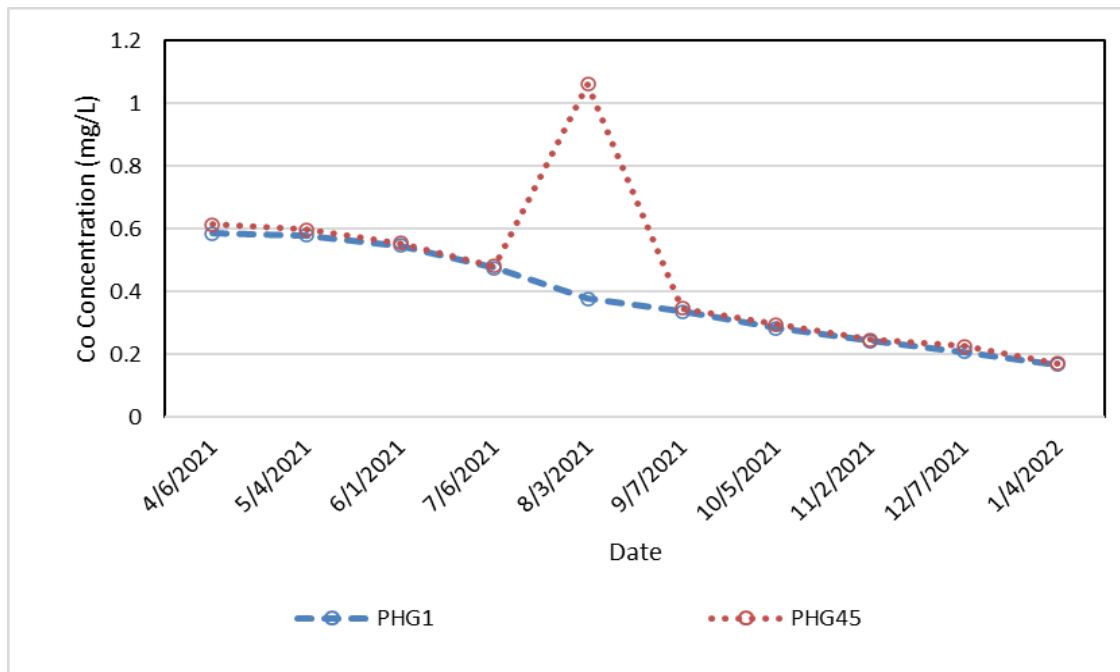
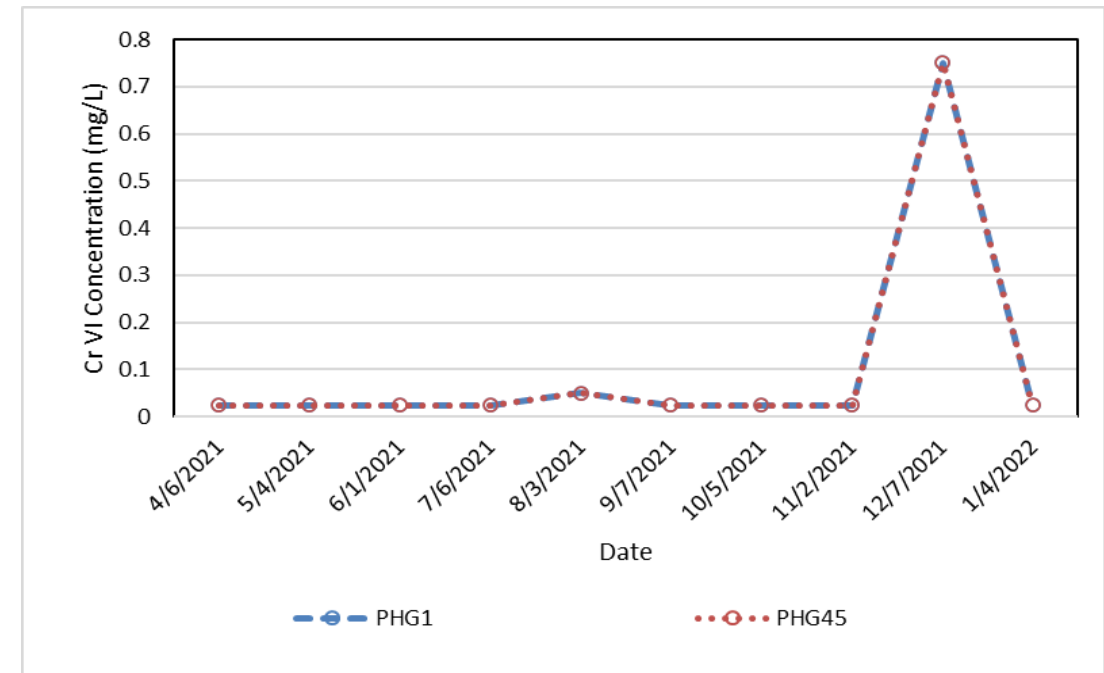
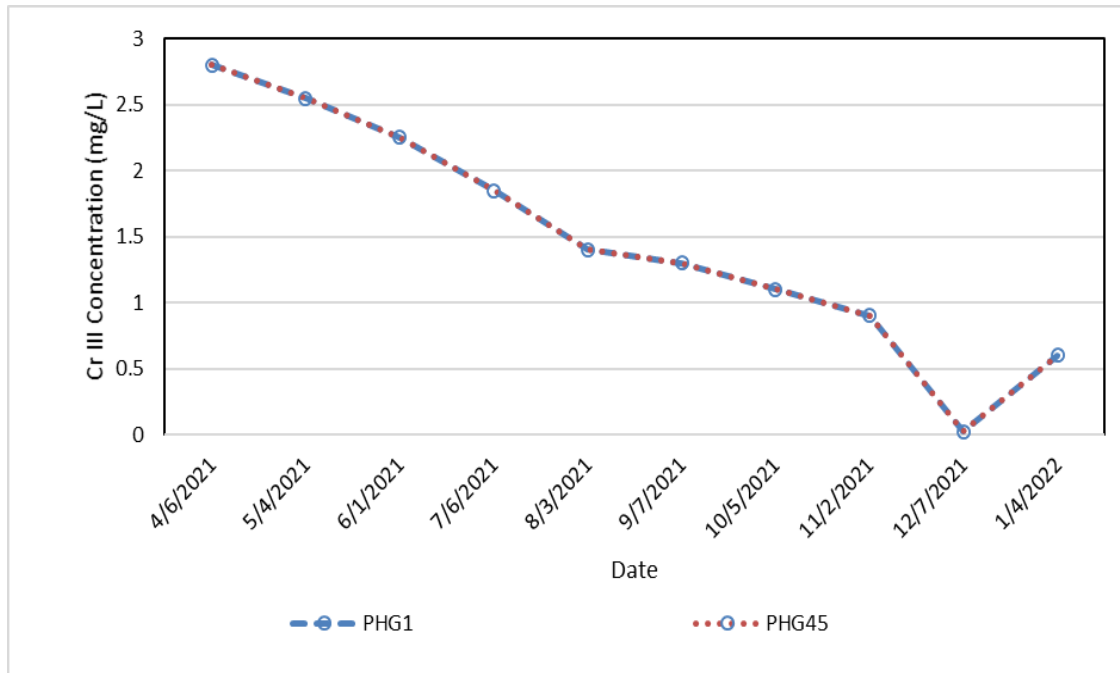
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PHG45	May-21	1.9	13,100	1160	0.580	0.83	0.842	2.55	0.025	1.730	13.90	47.8	1.8300	0.016	0.0005	11.20	0.01	0.0004	0.02	0.02	0.02	0.15	5.17
PHG45	Jun-21	2	12,500	1050	0.528	1.00	0.749	2.25	0.025	1.590	14.00	42.0	1.6700	0.042	0.00025	10.00	0.01	0.0004	0.02	0.02	0.02	0.14	4.36
PHG45	Jul-21	2.1	11,400	970	0.467	1.28	0.688	1.85	0.025	1.400	14.80	37.6	1.4500	0.022	0.0005	8.71	0.01	0.0004	0.02	0.03	0.02	0.13	1.00
PHG45	Aug-21	2.2	10,700	890		0.0009	0.08	1.4	0.050	1.140	14.00	32.1	1.1400	0.022	0.00005	6.95	0.00	0.0009	0.02	0.03	0.02	0.11	3.50
PHG45	Sep-21	2.1	9,240	806	0.321	0.71	0.527	1.3	0.025	1.050		28.9	1.0400	0.050	0.00025	6.46	0.01	0.0005	0.02	0	0.02	0.10	3.73
PHG45	Oct-21	2.2	8,820	719	0.270	0.84	0.471	1.1	0.025	0.904		25.1	0.8790	0.018	0.00025	5.32	0.01	0.0005	0.02	0	0.02	0.09	2.91
PHG45	Nov-21	2.2	8,360	628	0.227	1.22	0.469	0.9	0.025	0.794		22.3	0.7470	0.014	0.00025	4.82	0.01	0.0005	0.02	0	0.01	0.09	2.92
PHG45	Dec-21	2.2	7,980	583	0.186	0.61	0.498	0.025	0.750	0.769		21.0	0.6800	0.014	0.00025	3.63	0.01	0.0188	0.02	0	0.01	0.08	3.03
PHG45	Jan-22	2.3	7,120	564	0.172	0.66	0.421	0.6	0.025	0.587	9.58	20.6	0.5090	0.014	0.00025	3.03	0.01	0.0007	0.01	0.04	0.01	0.07	2.79

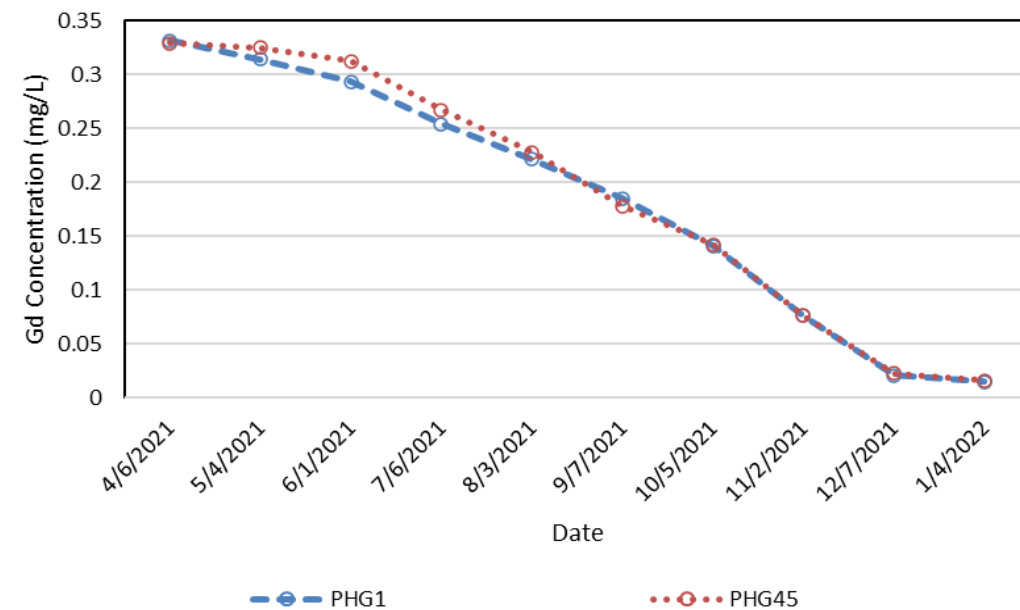
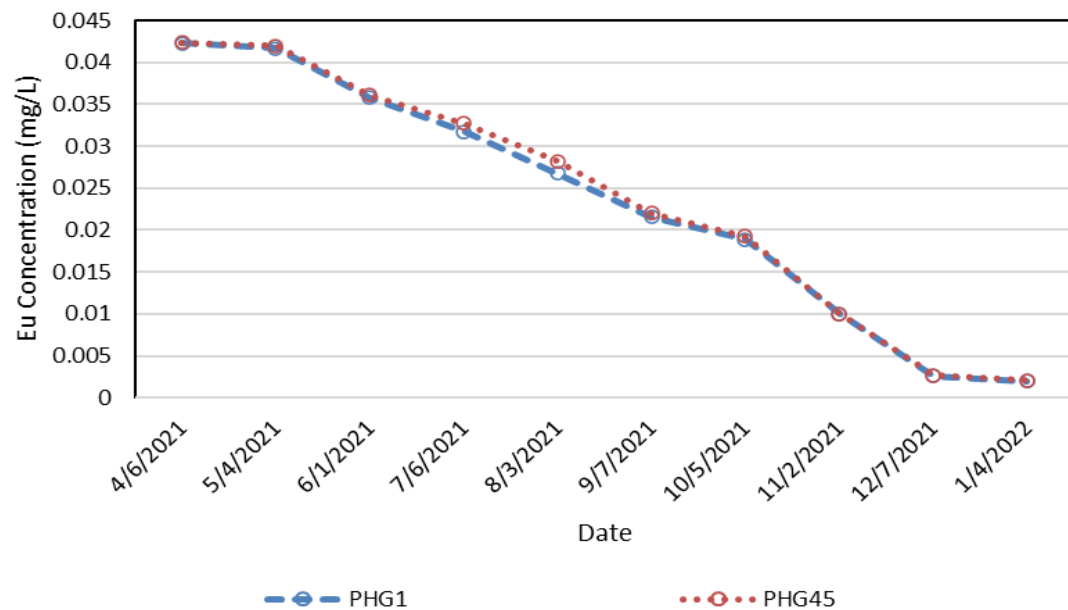
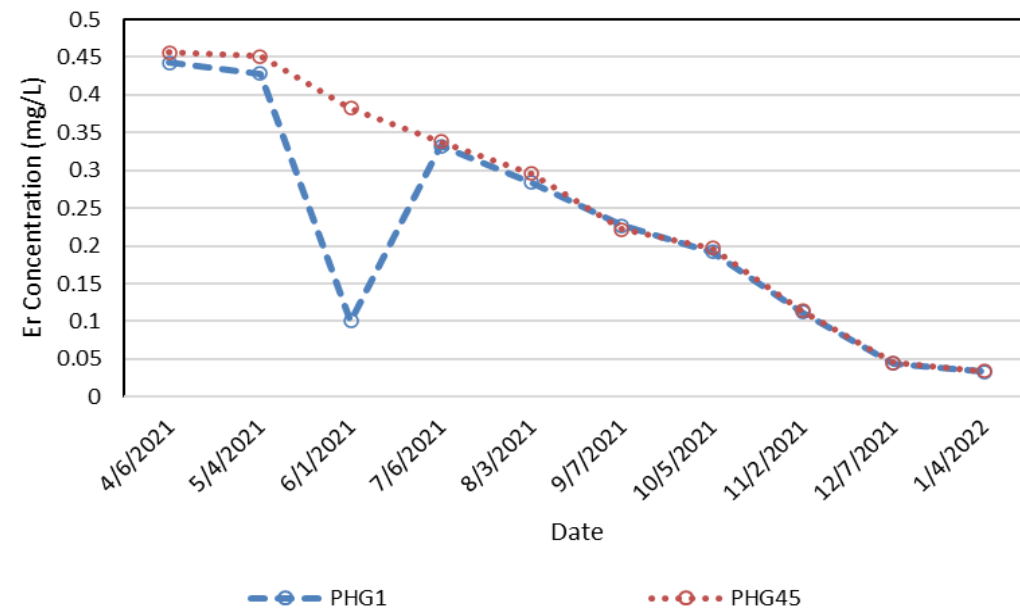
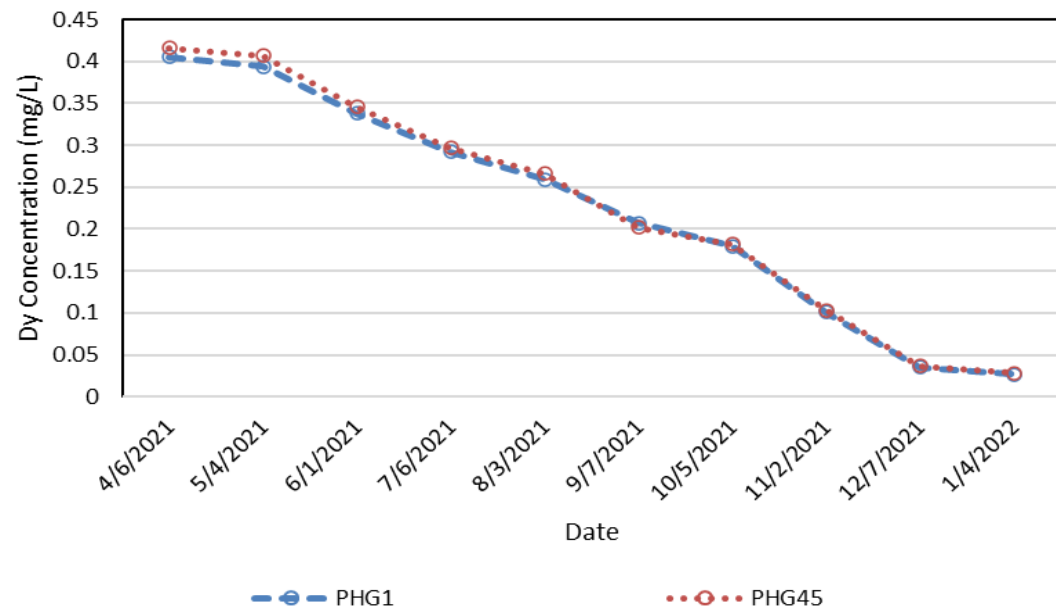
ANZAST (2018) FAE 95%
Greater than guideline
Ten times greater than guideline
100 times greater than guideline
1000 times greater than guideline

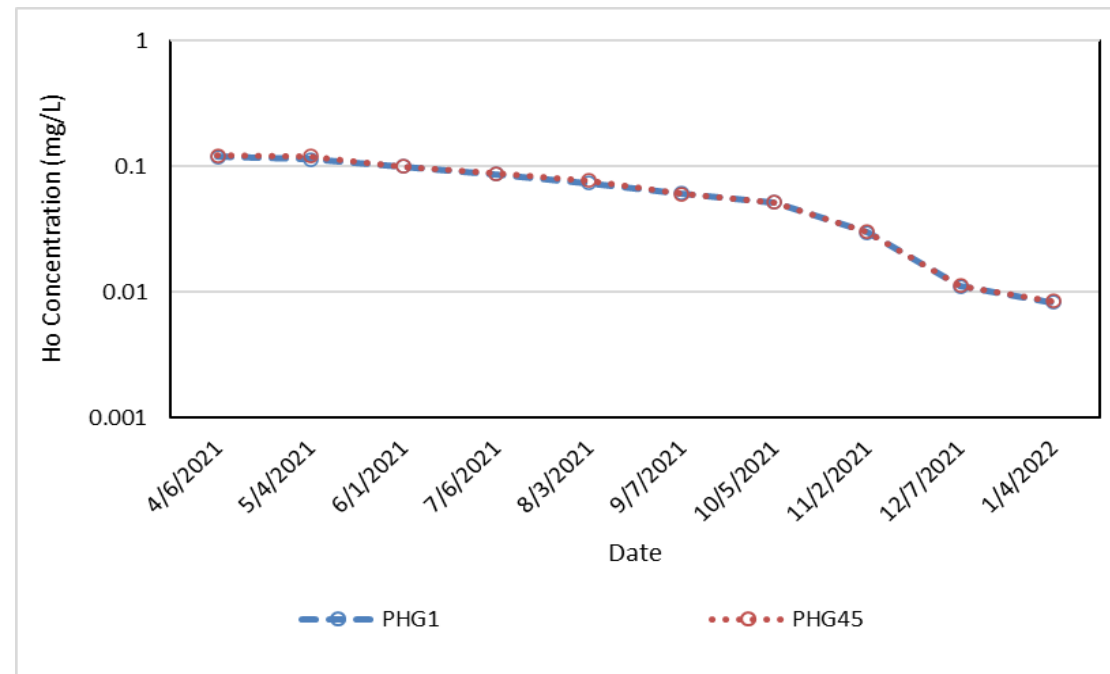
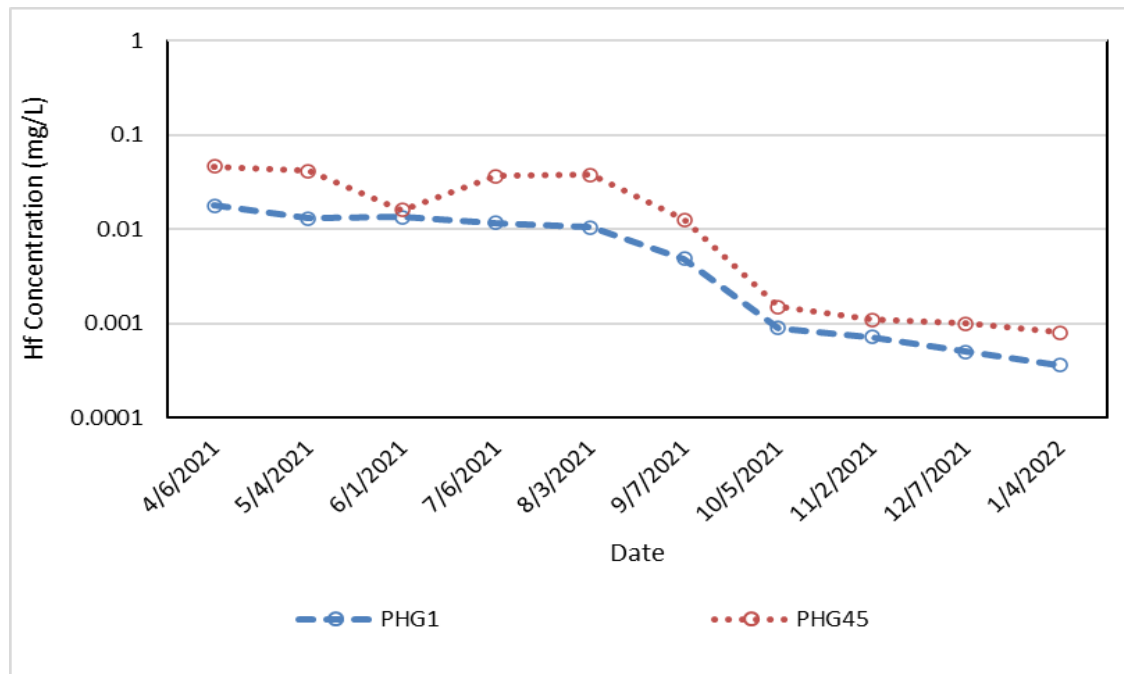
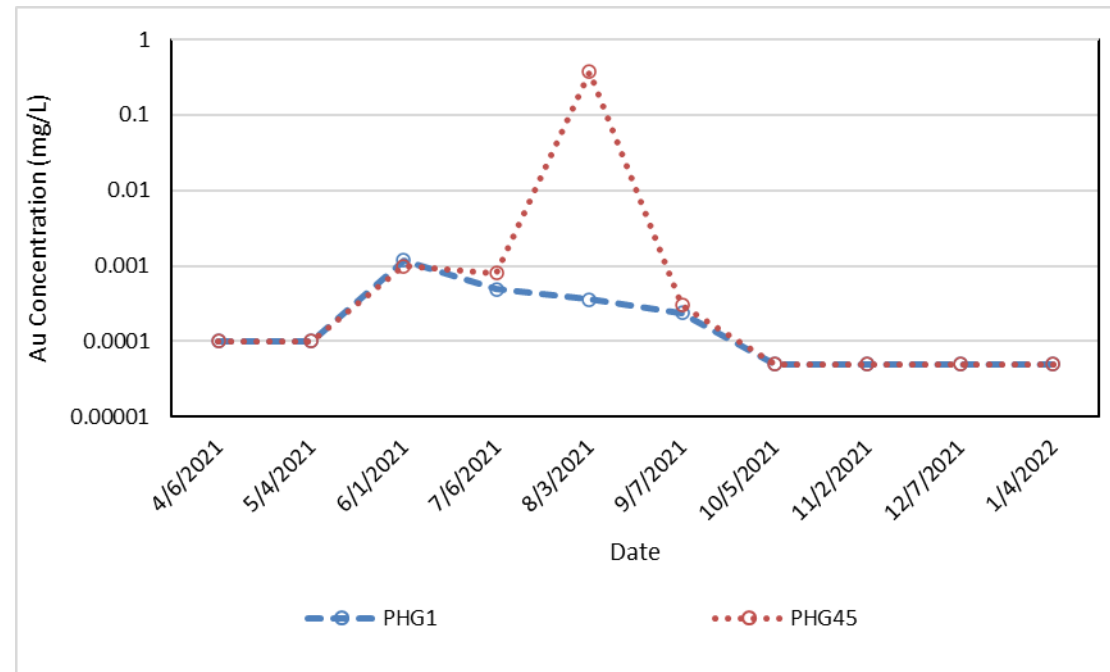
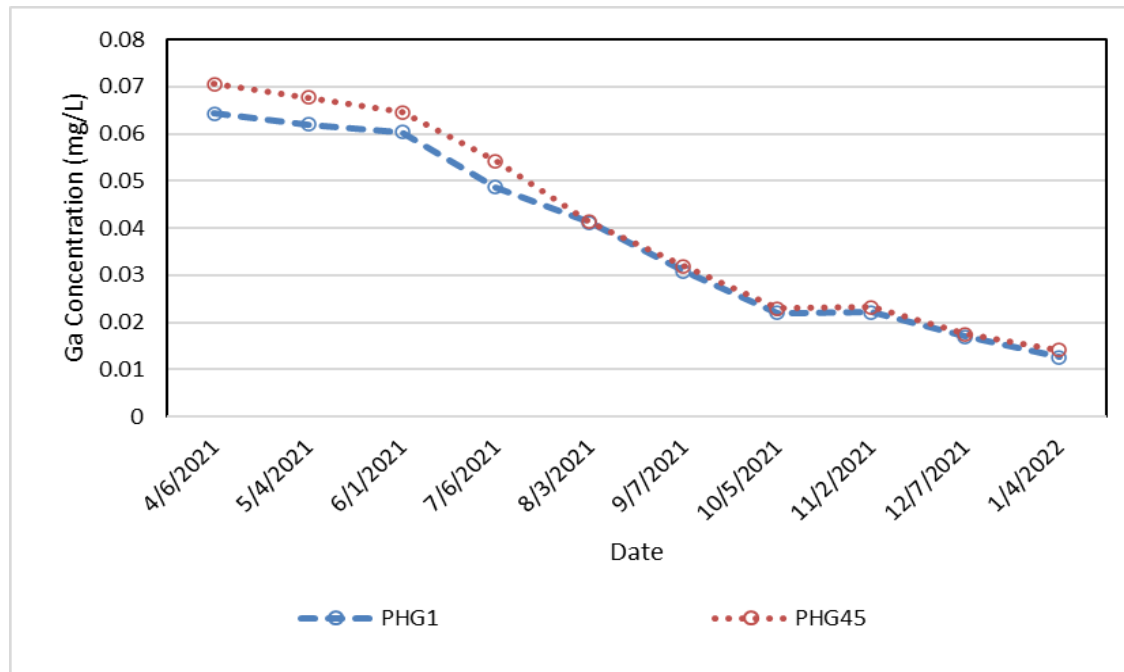


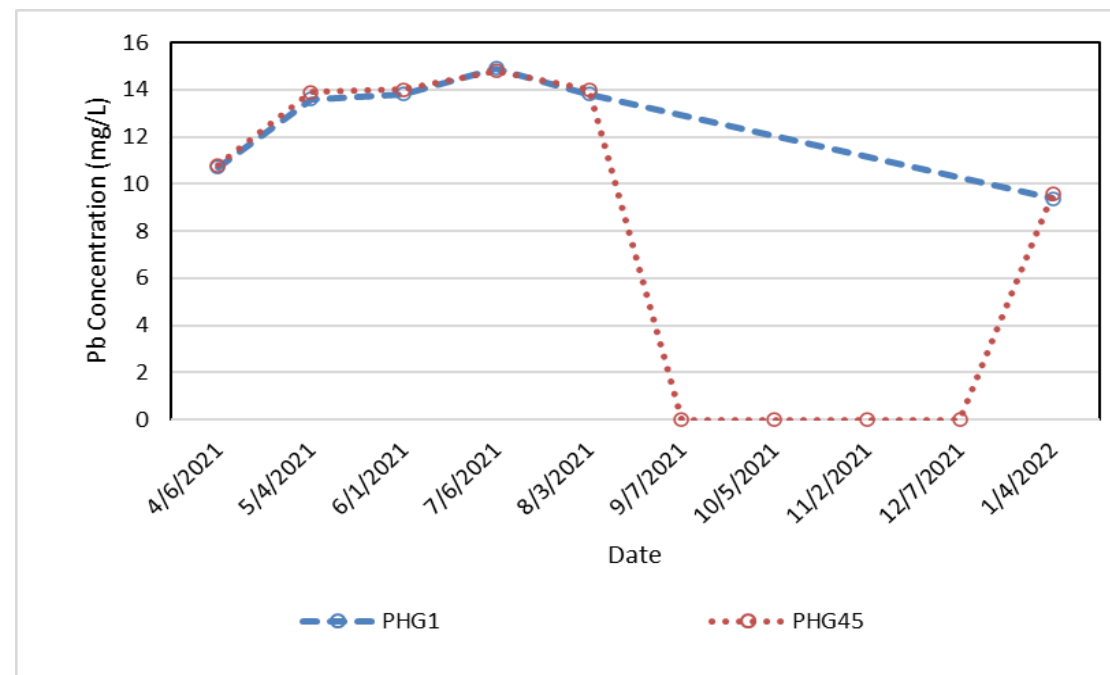
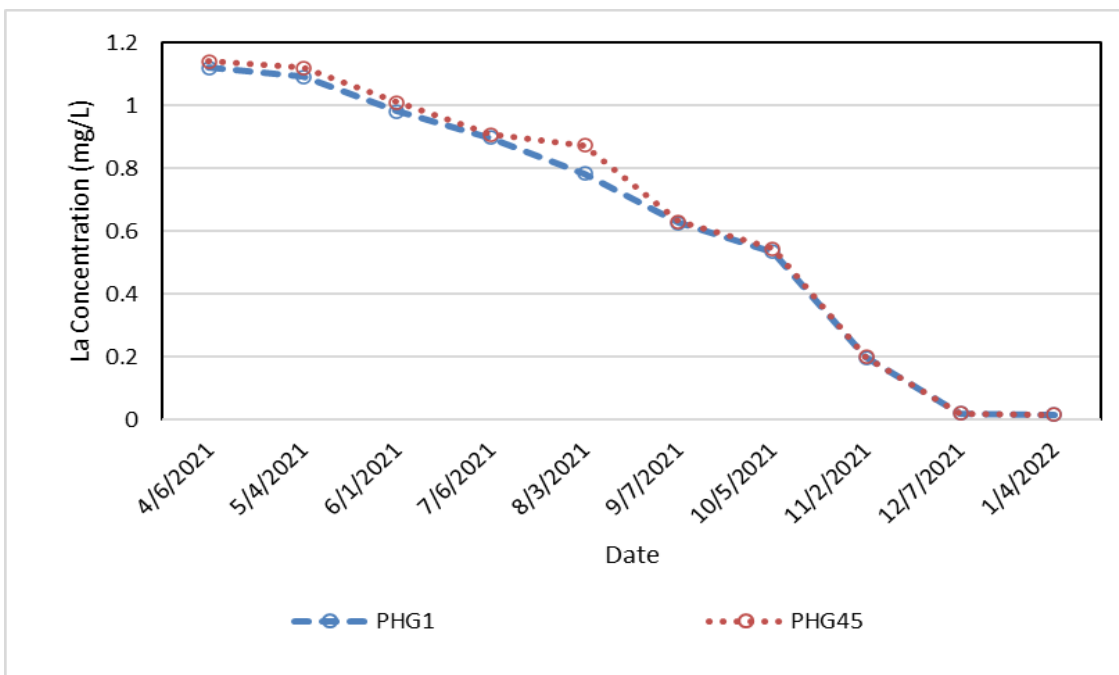
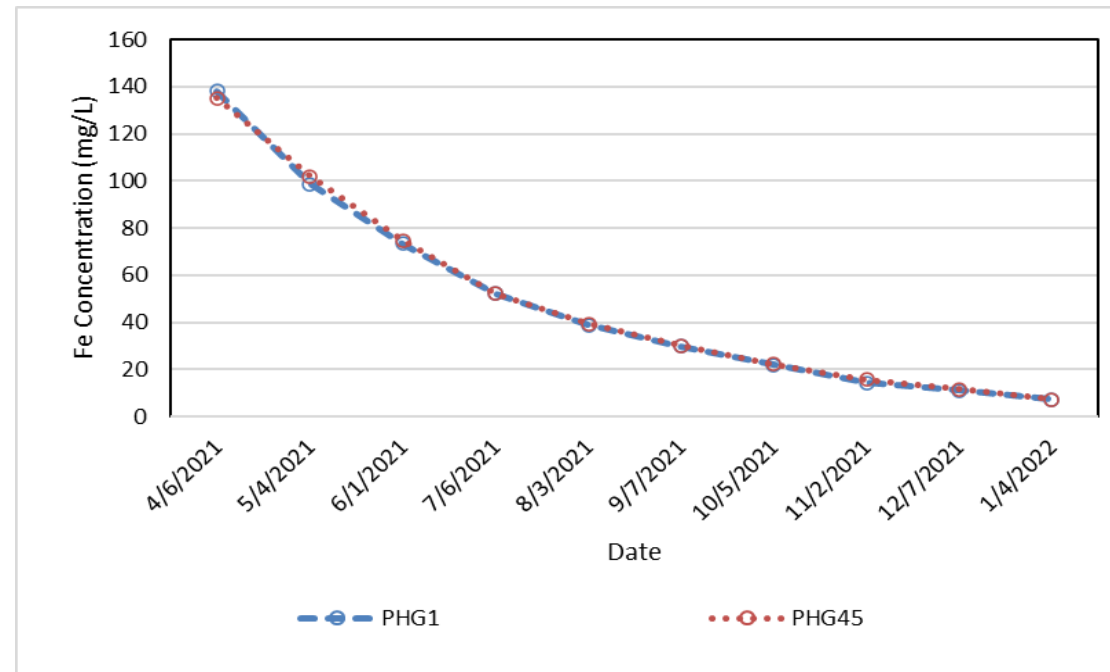
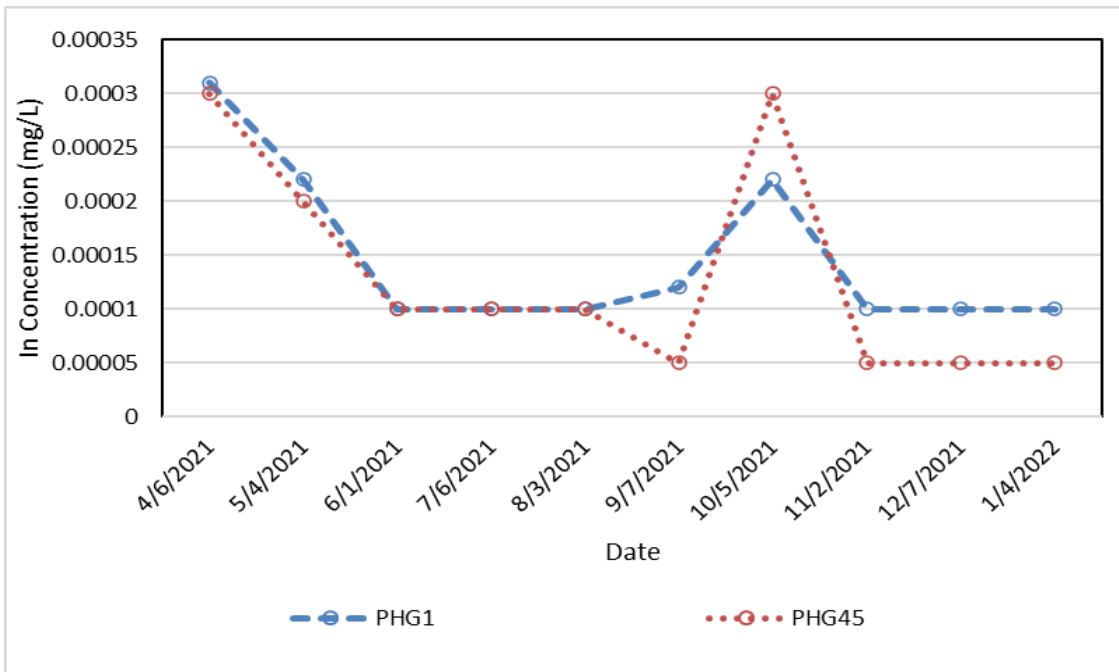


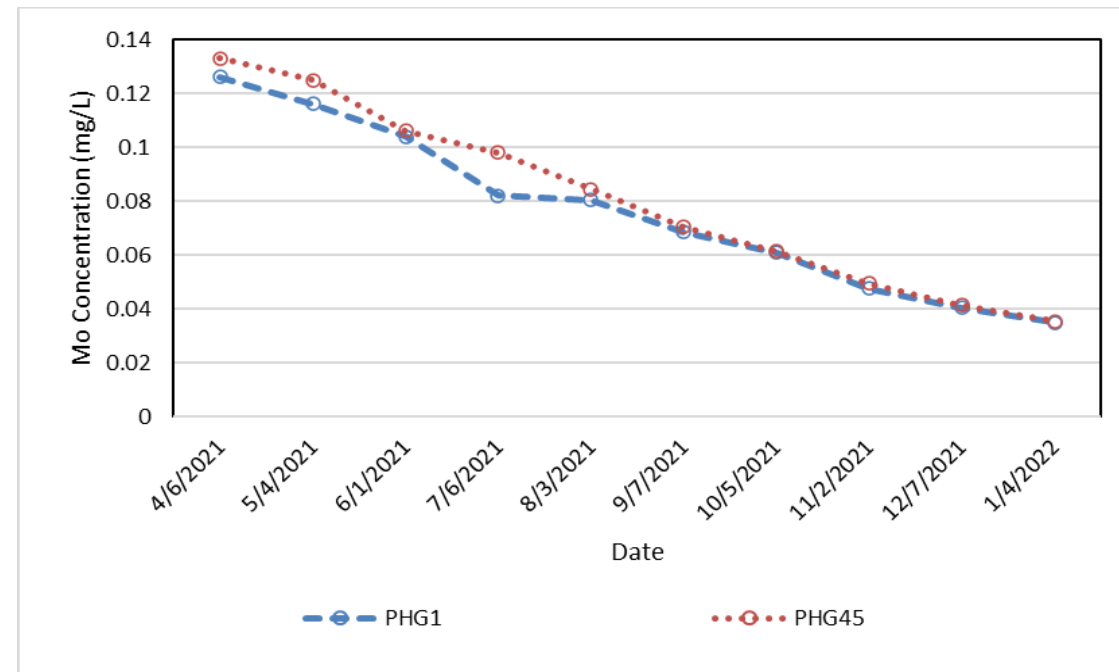
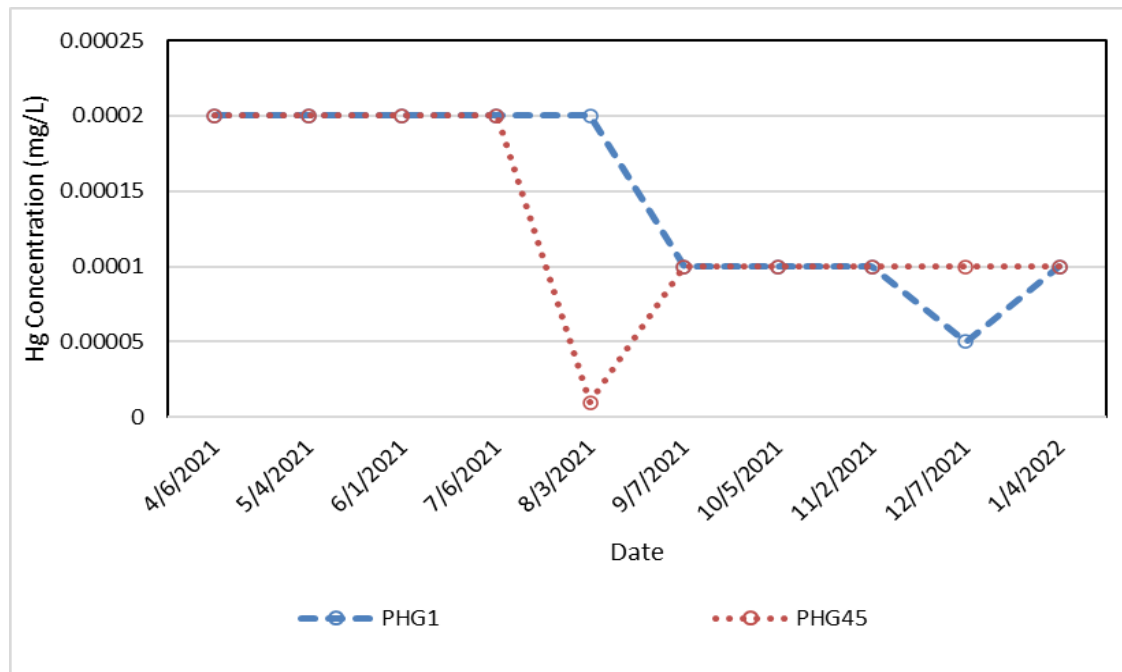
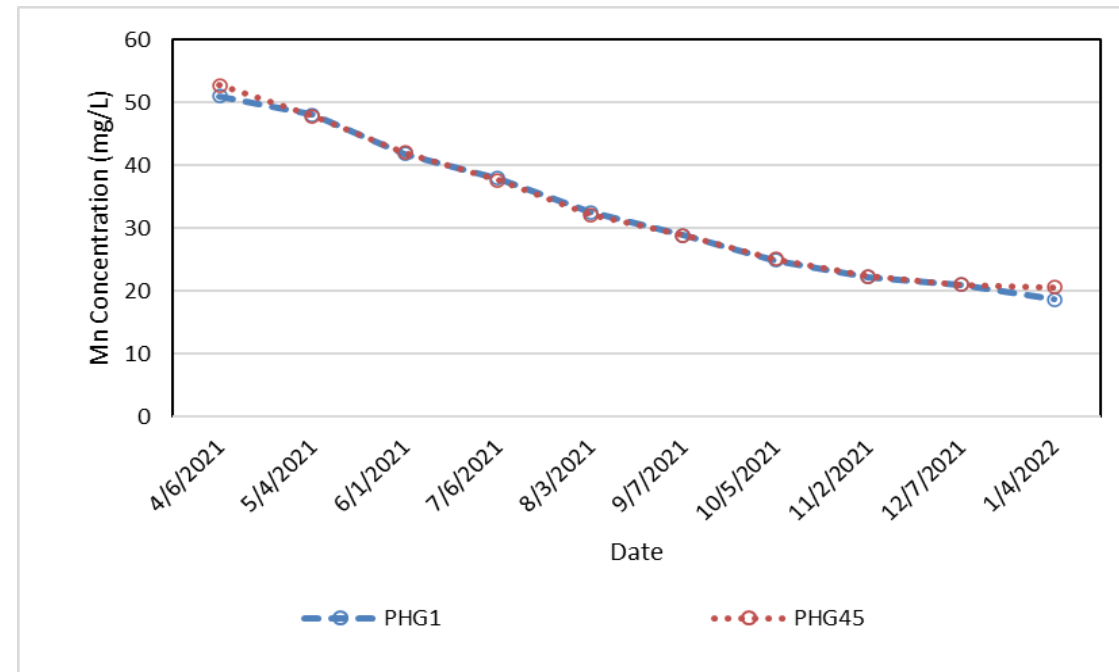
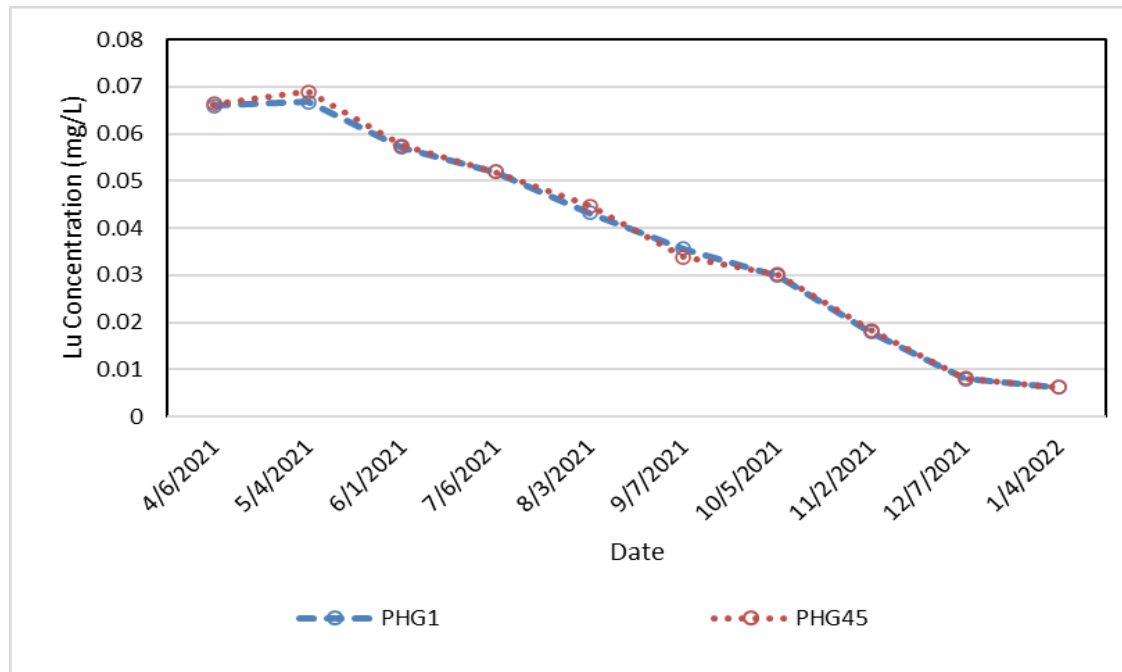


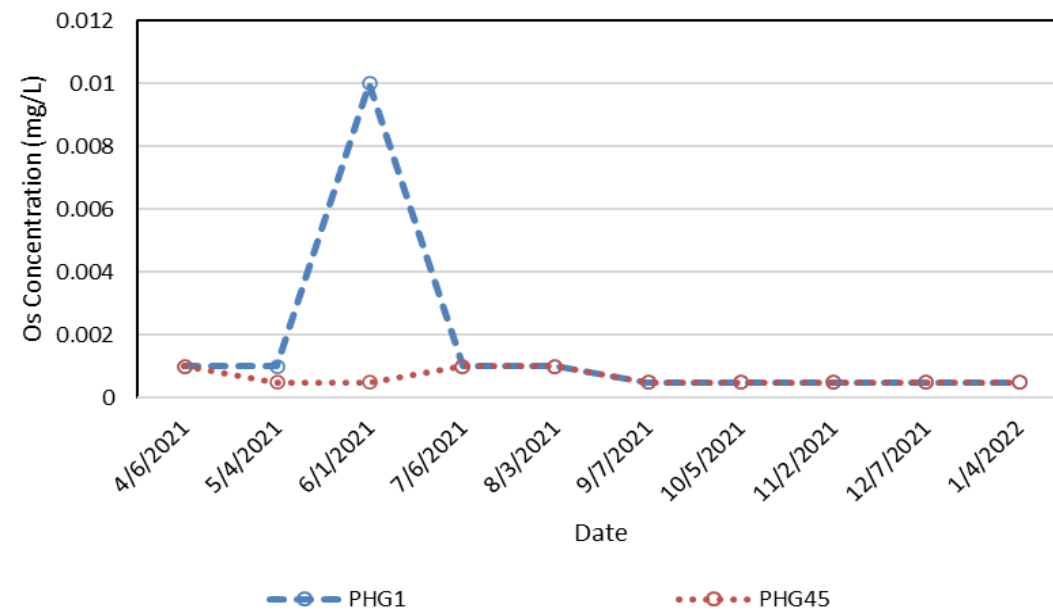
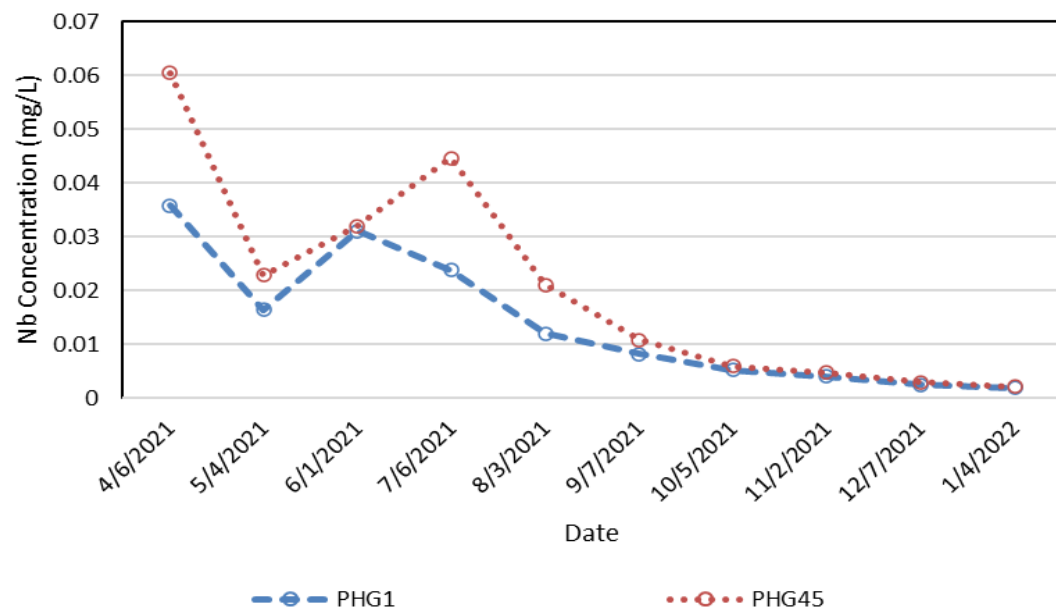
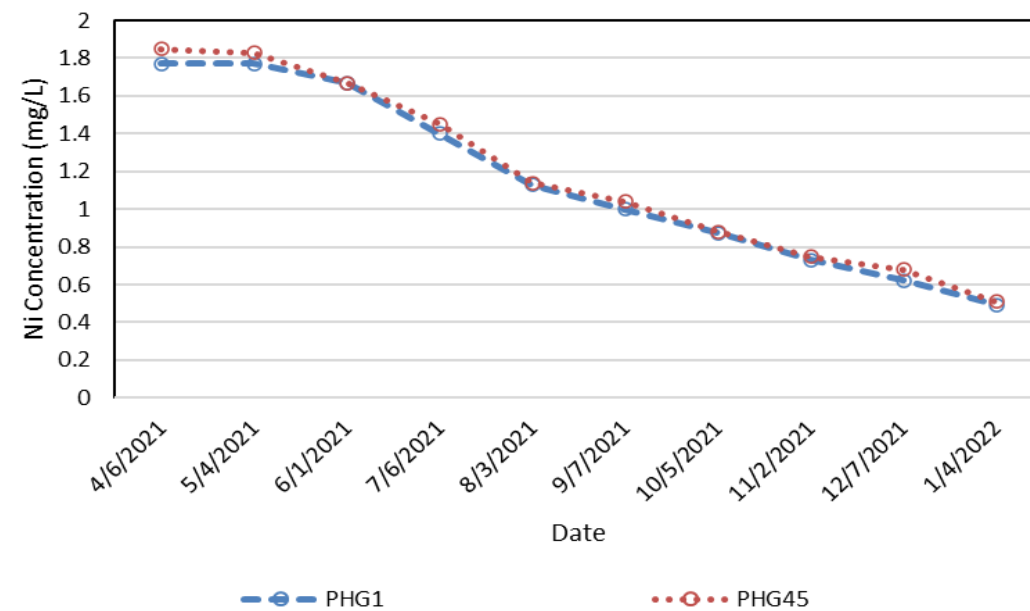
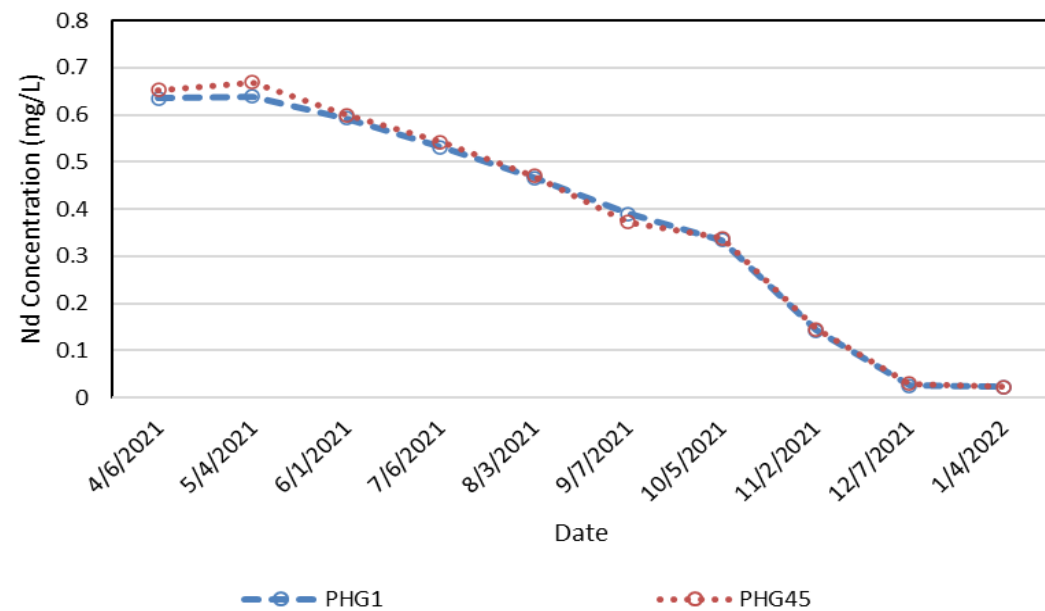


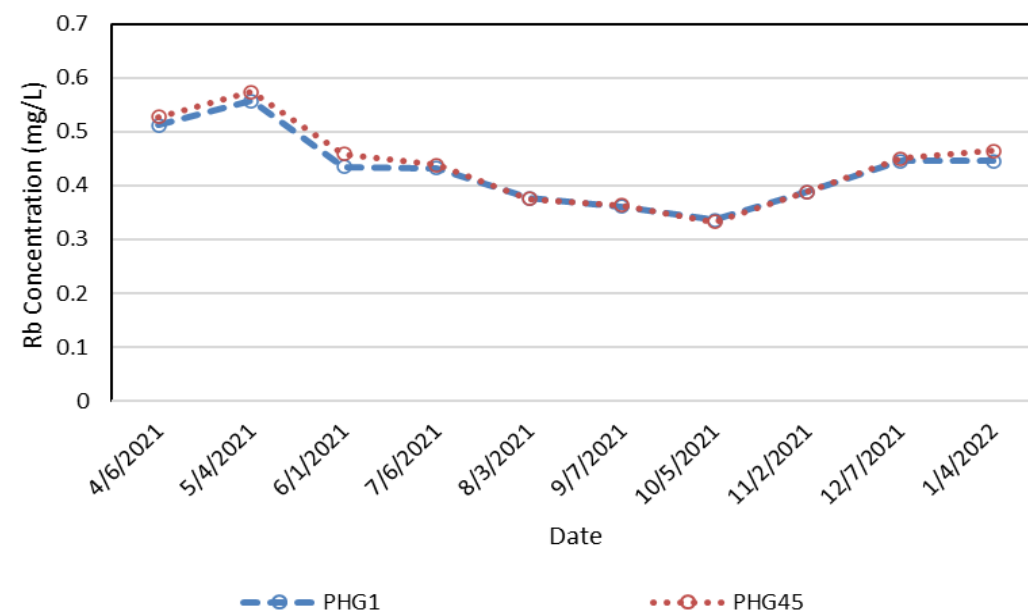
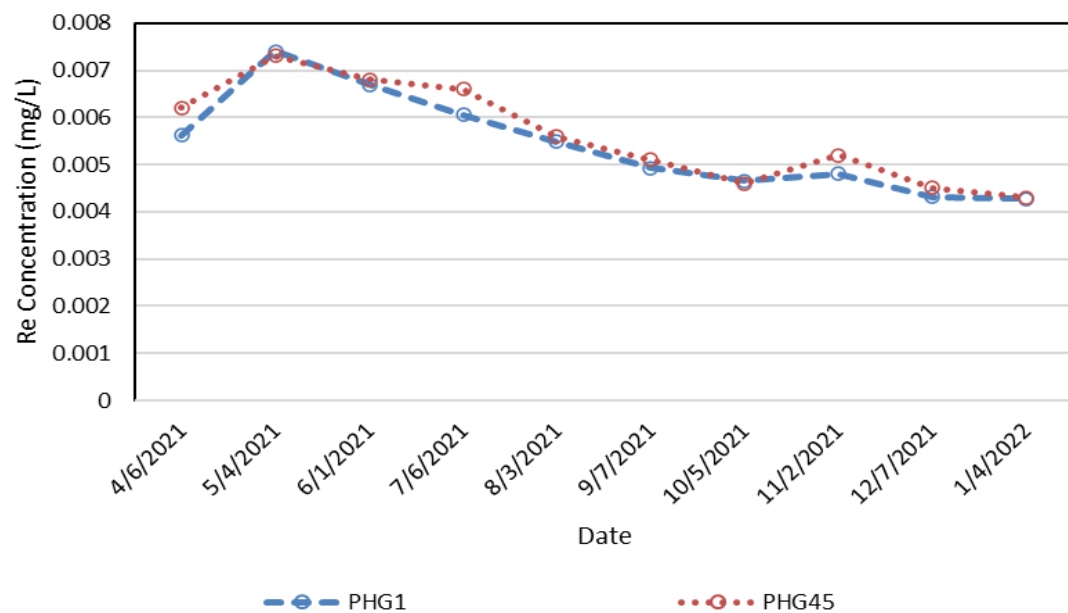
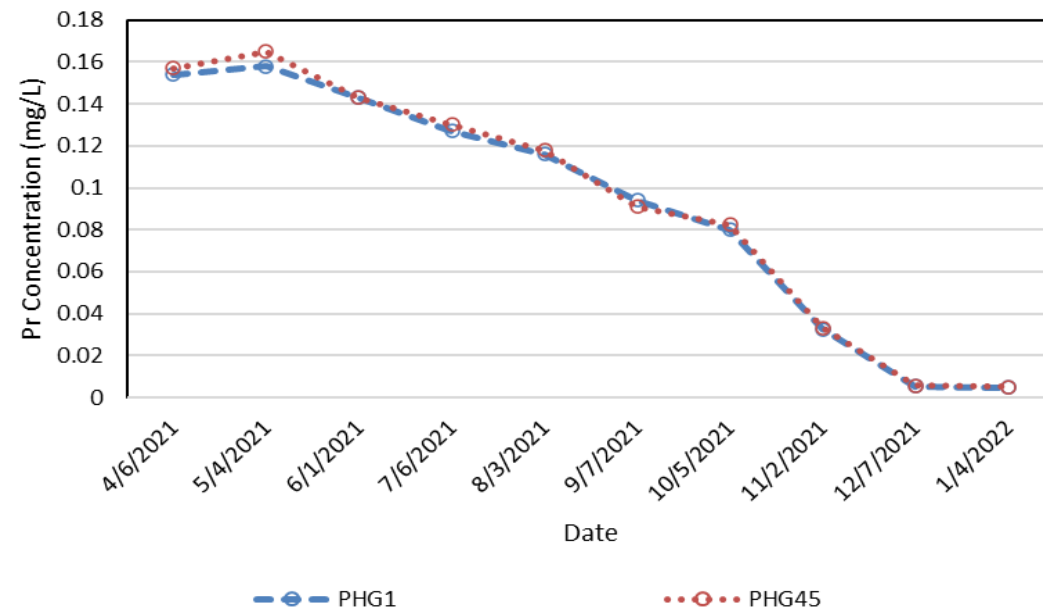
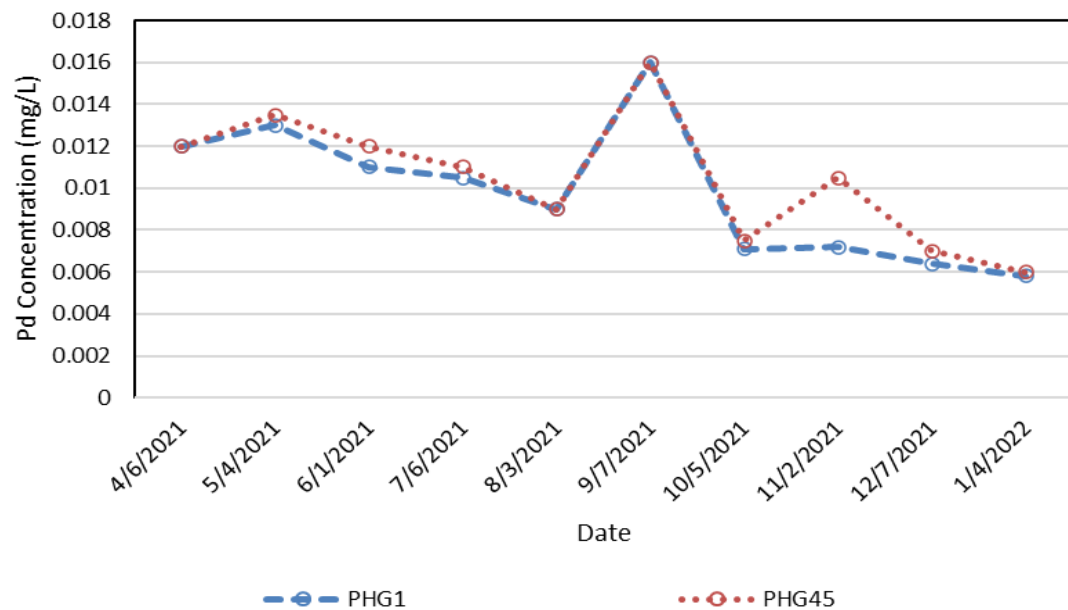


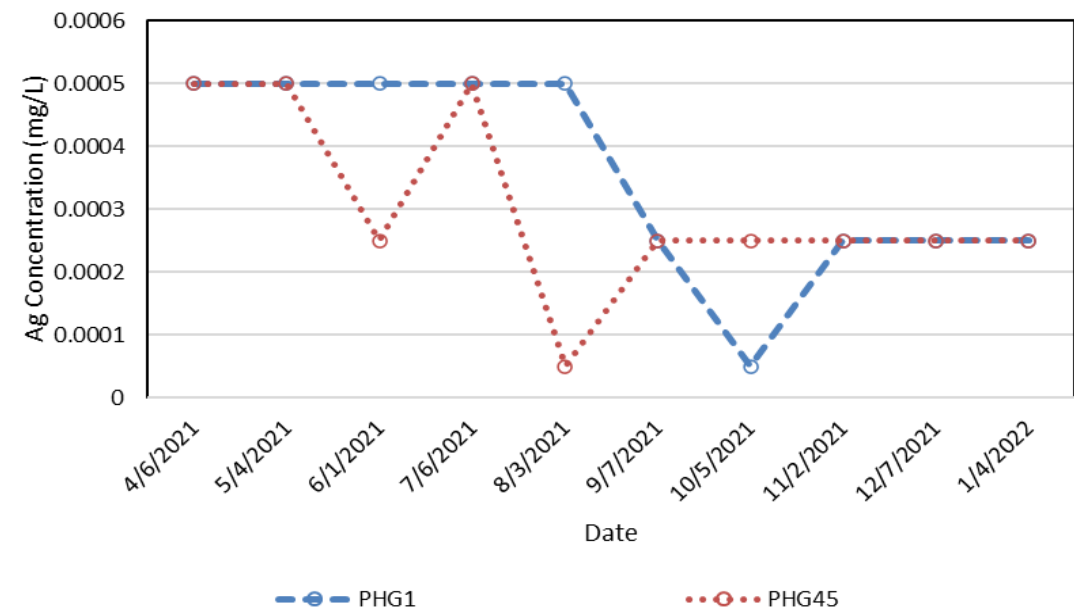
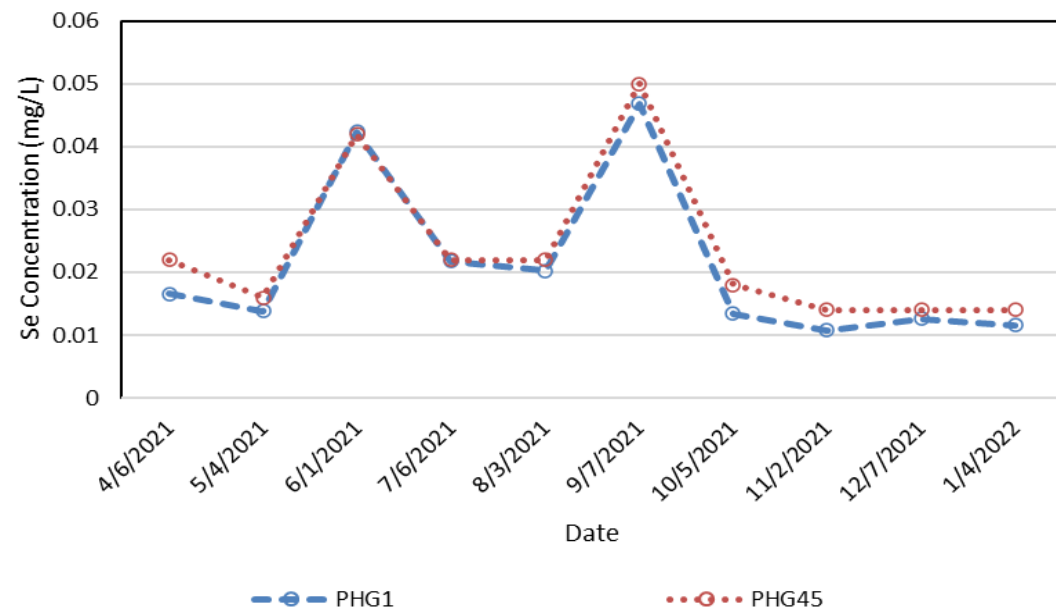
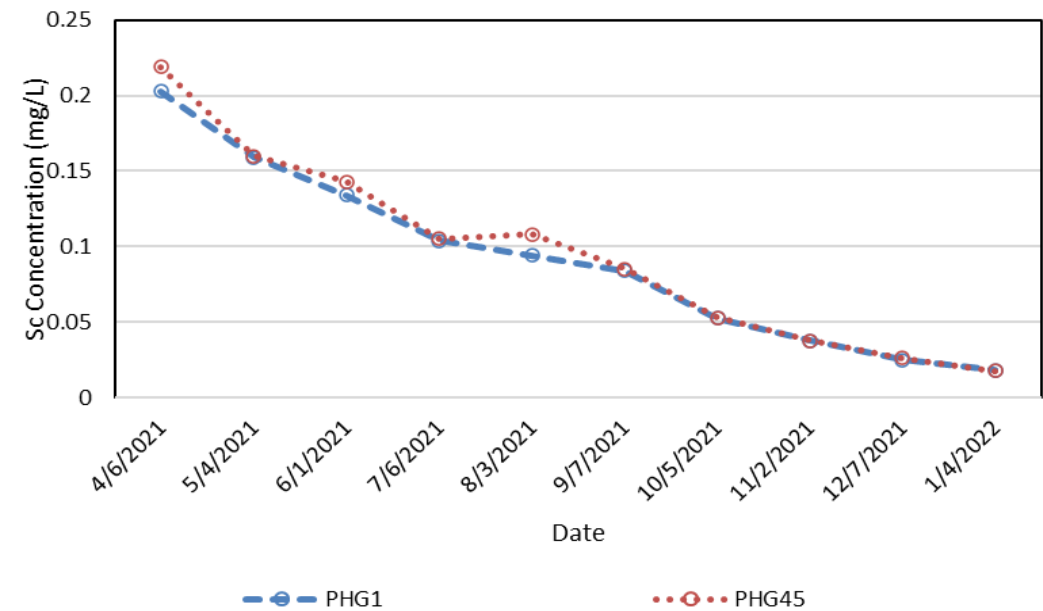
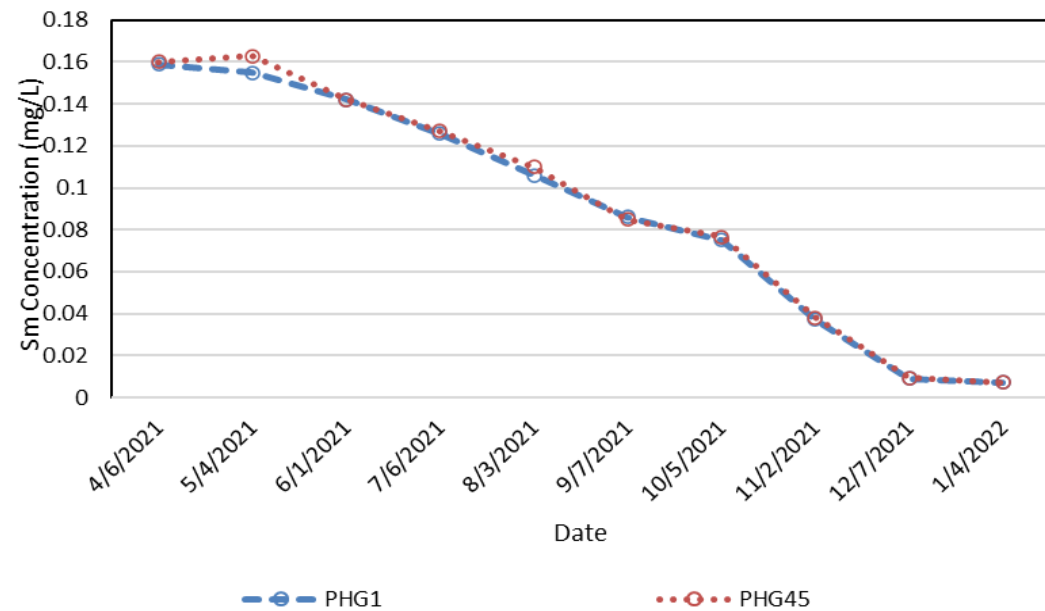


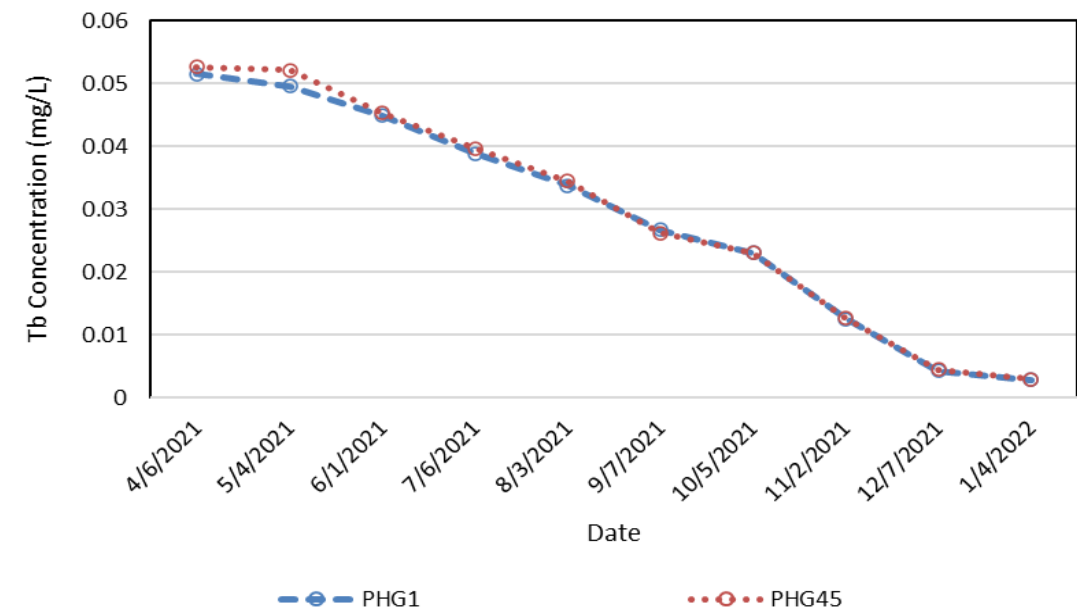
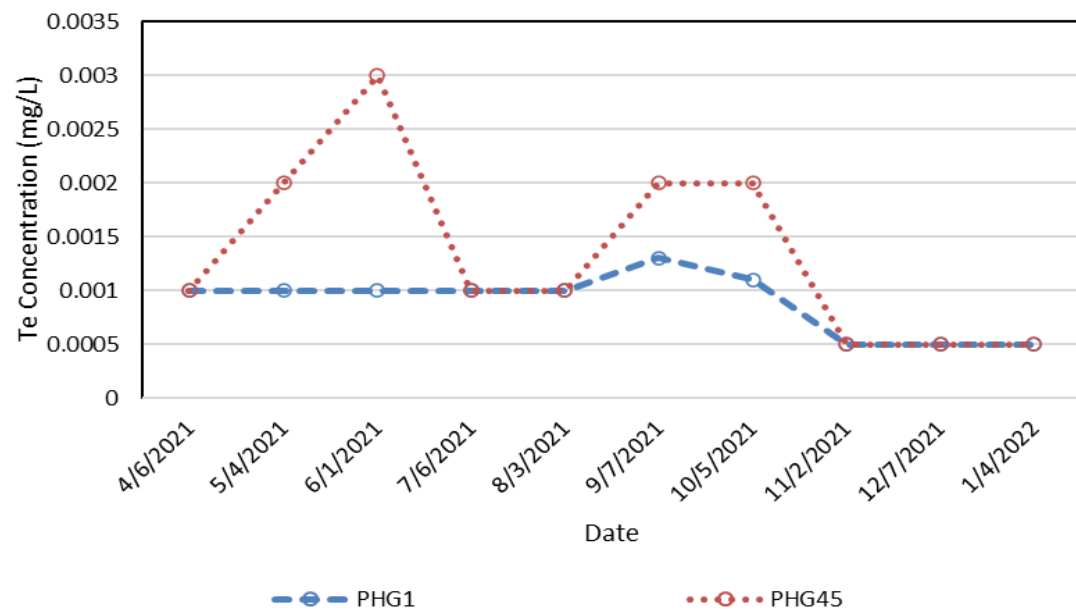
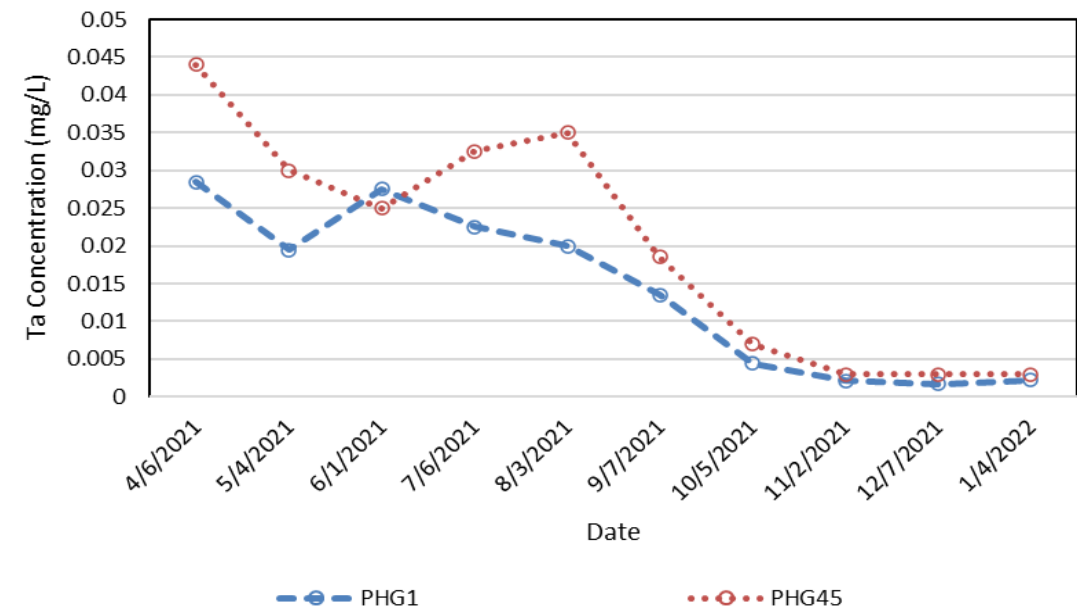
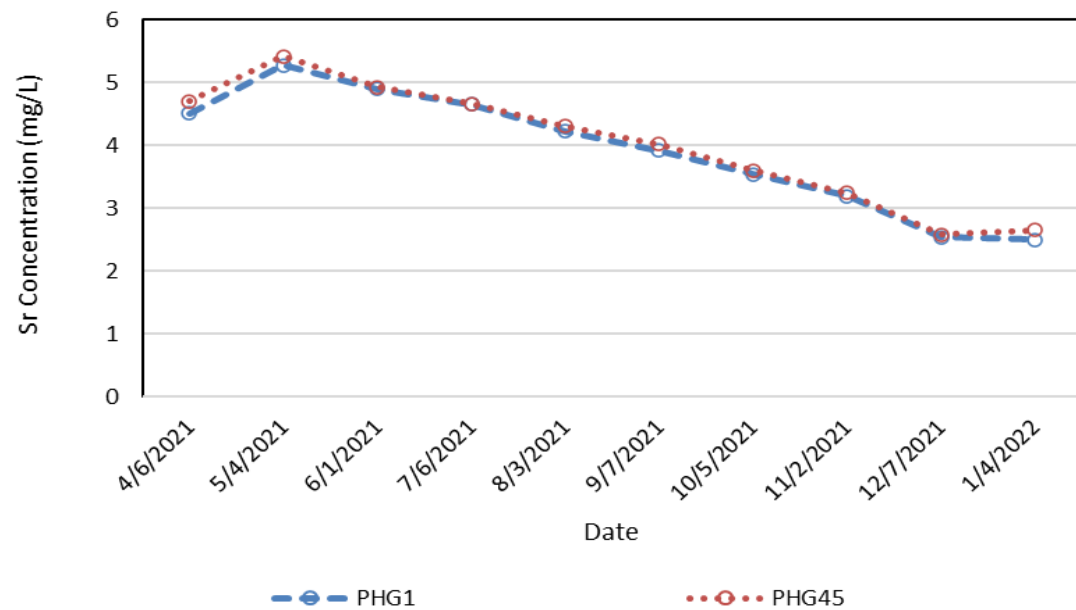


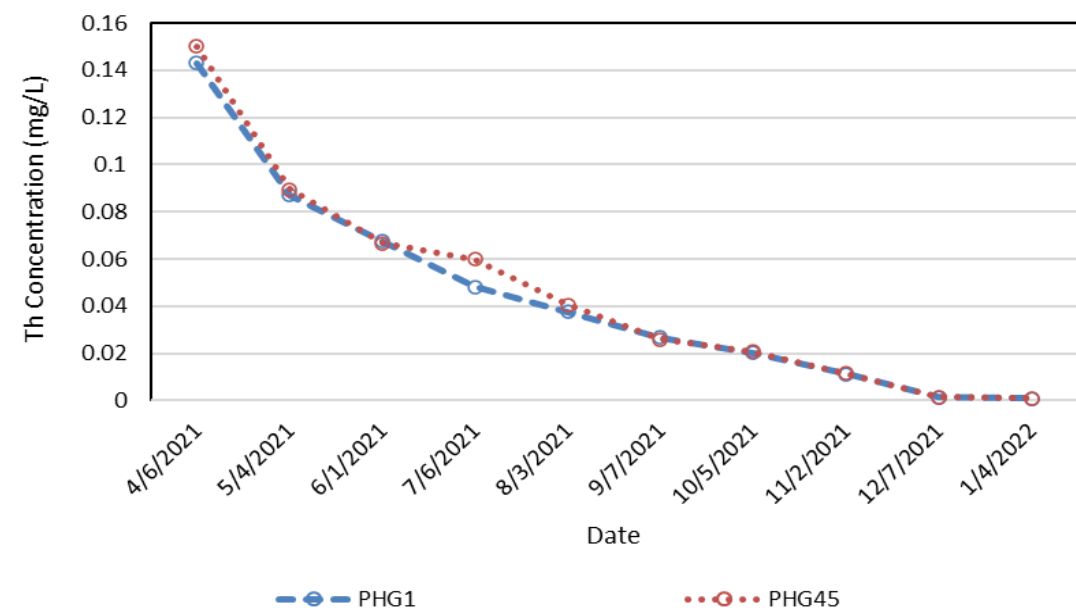
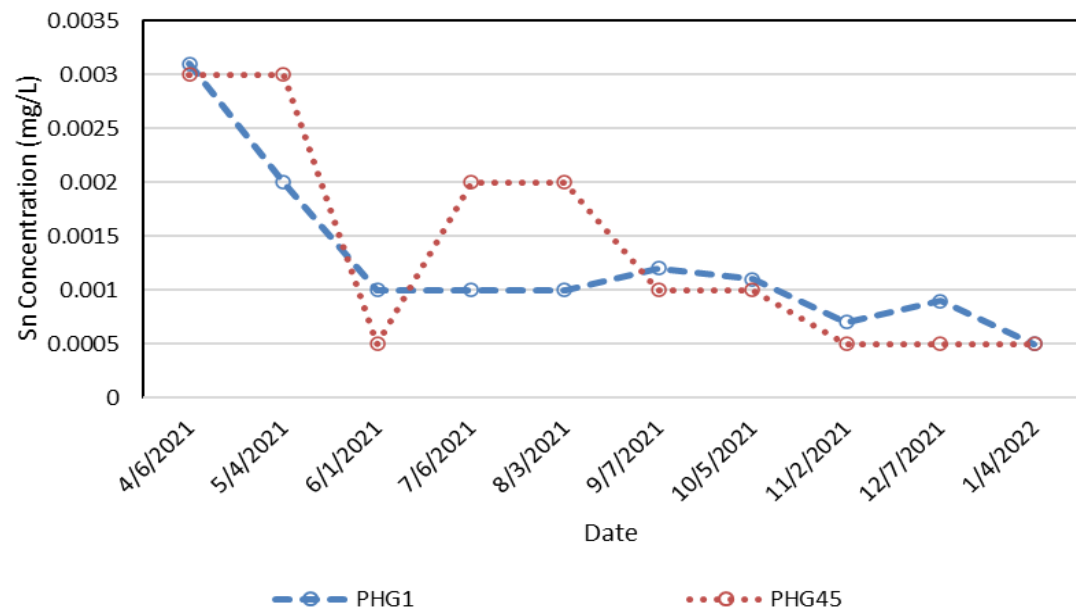
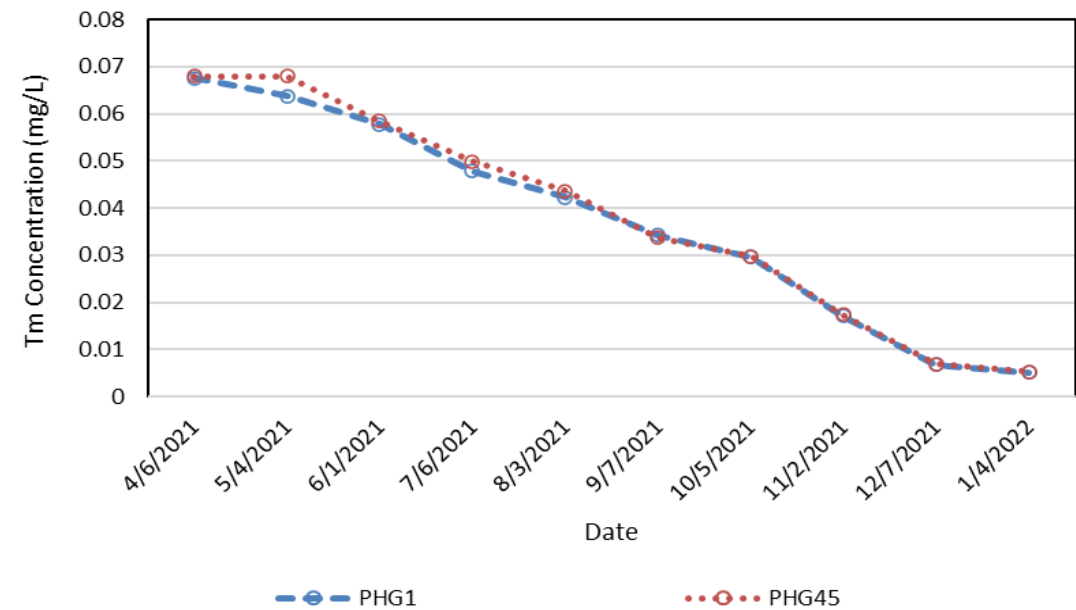
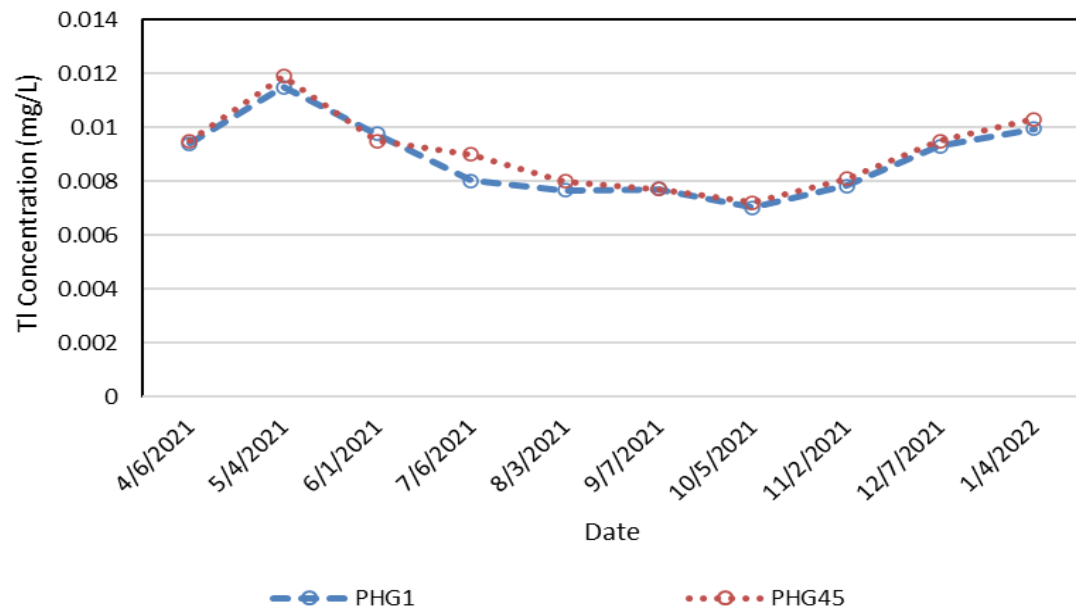


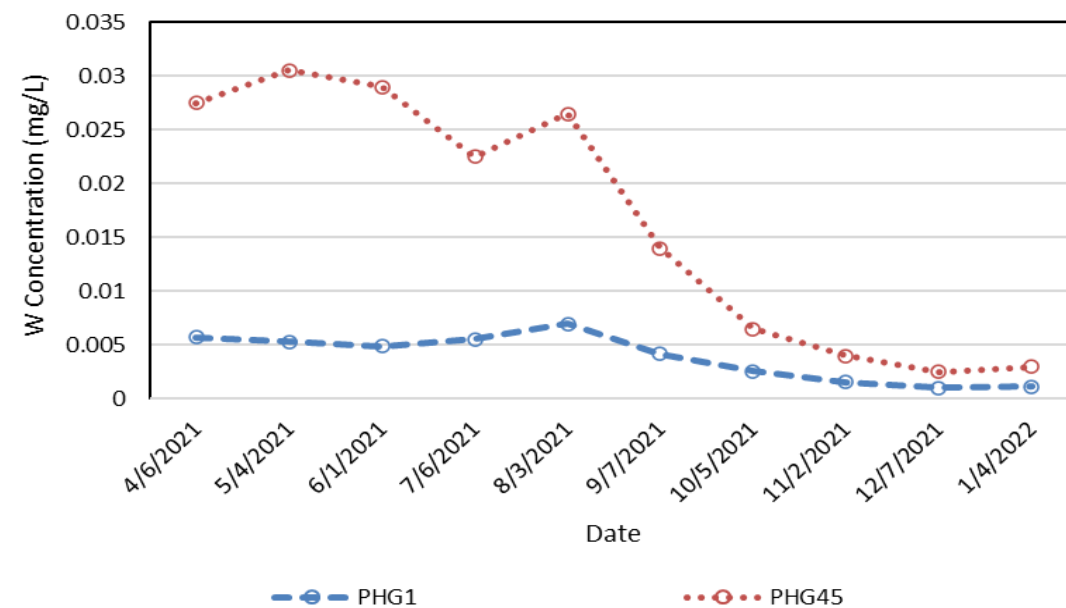
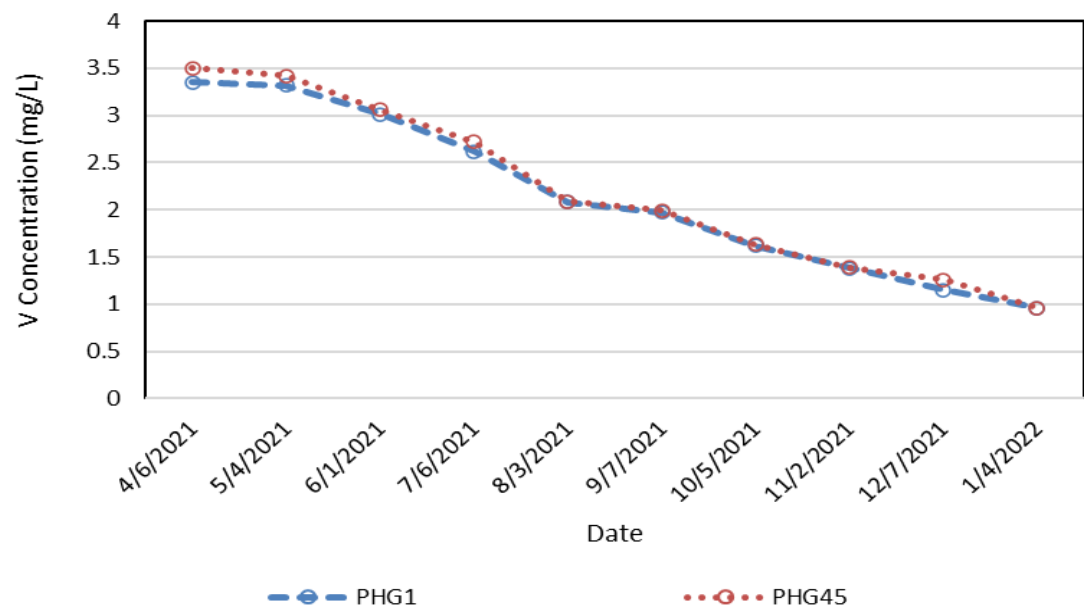
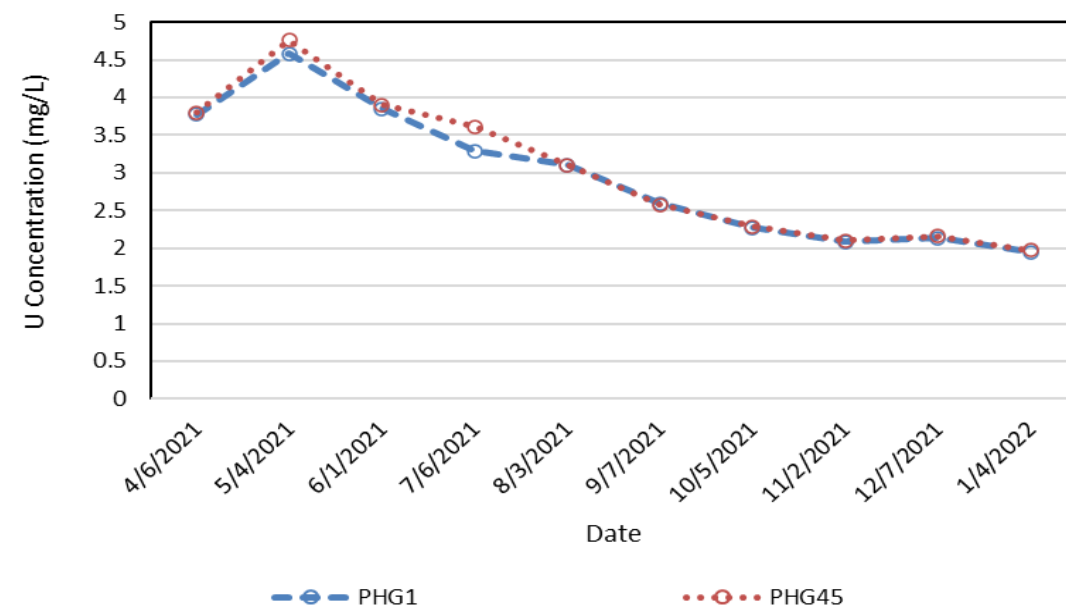
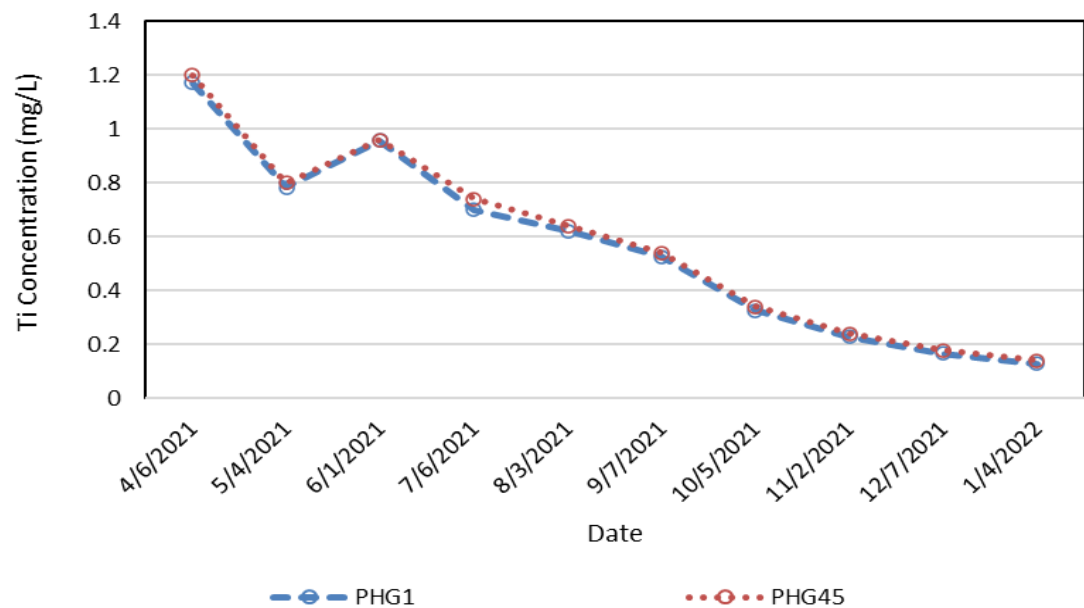


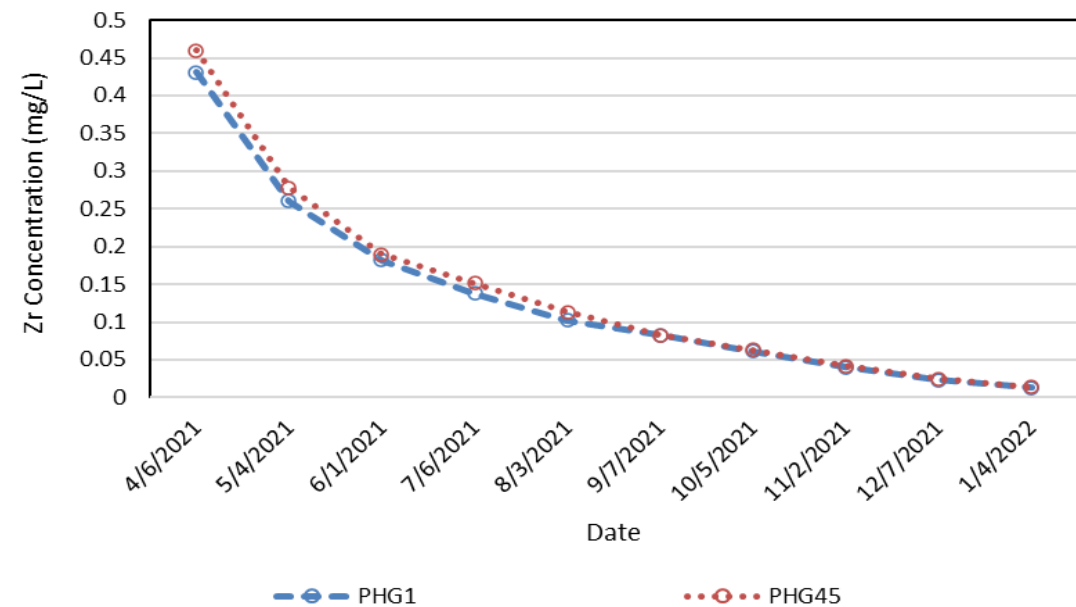
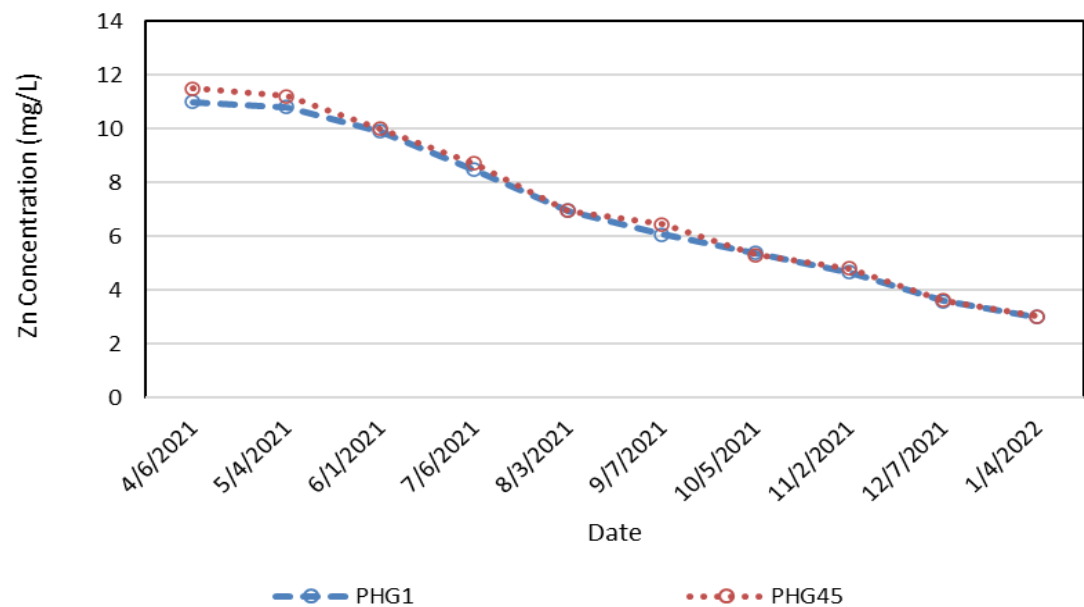
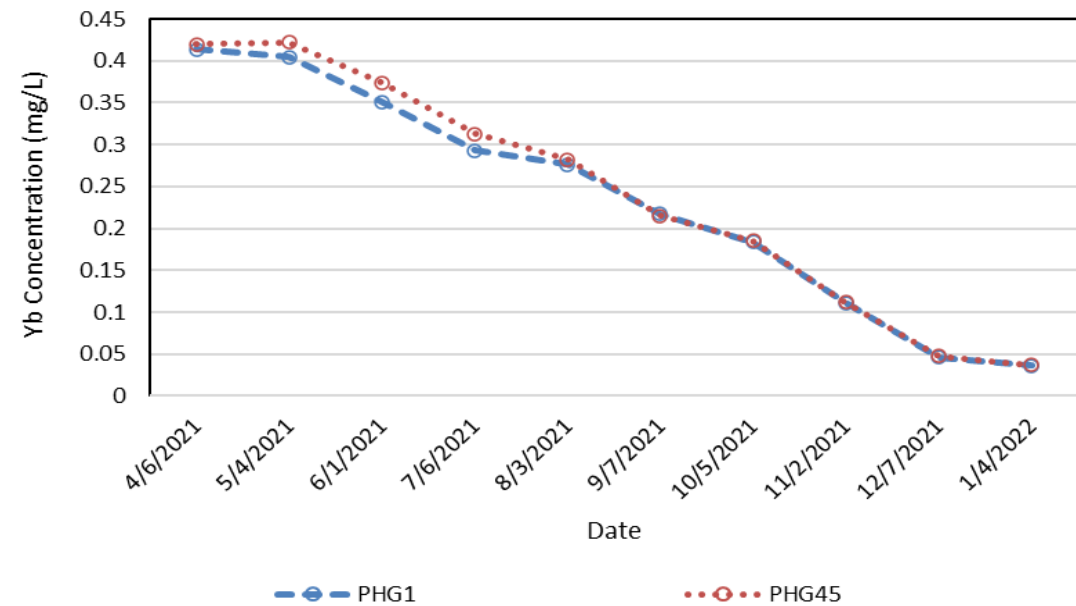
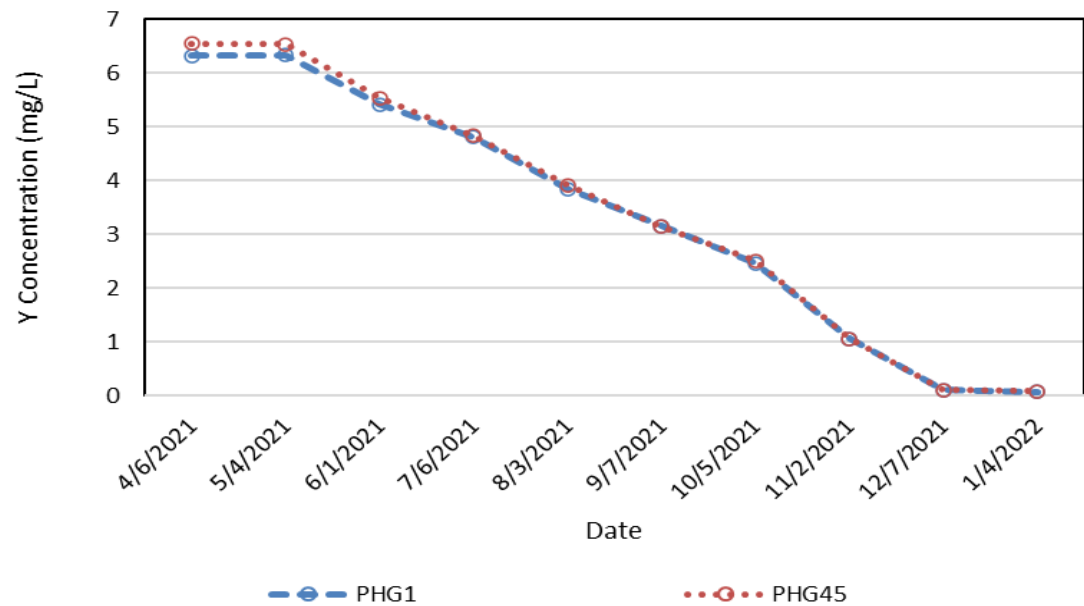


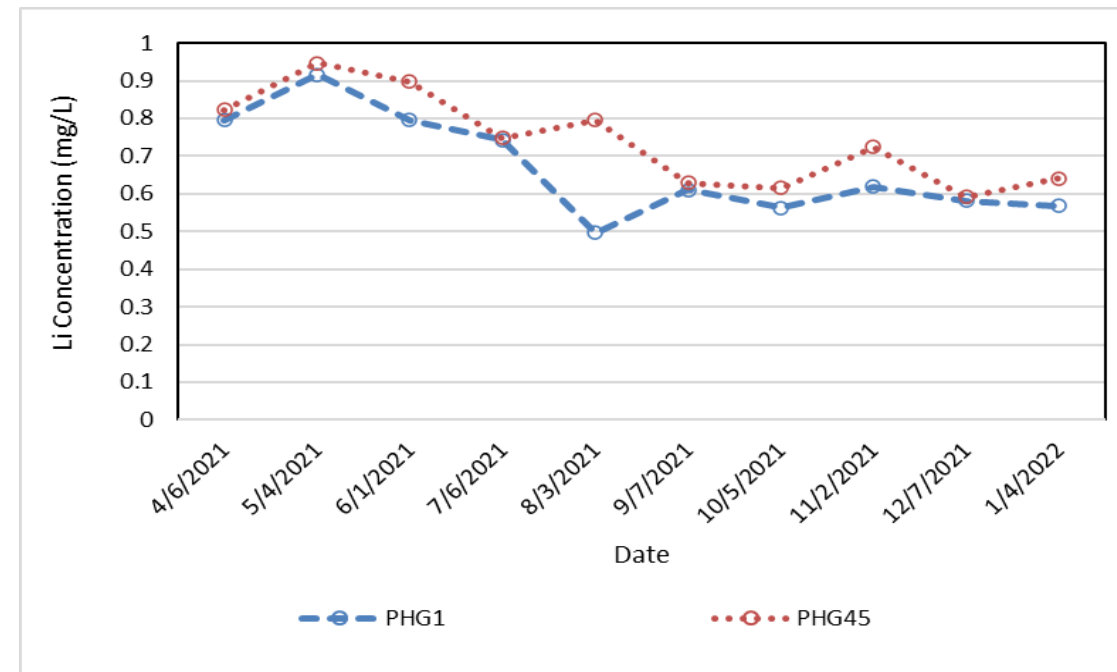
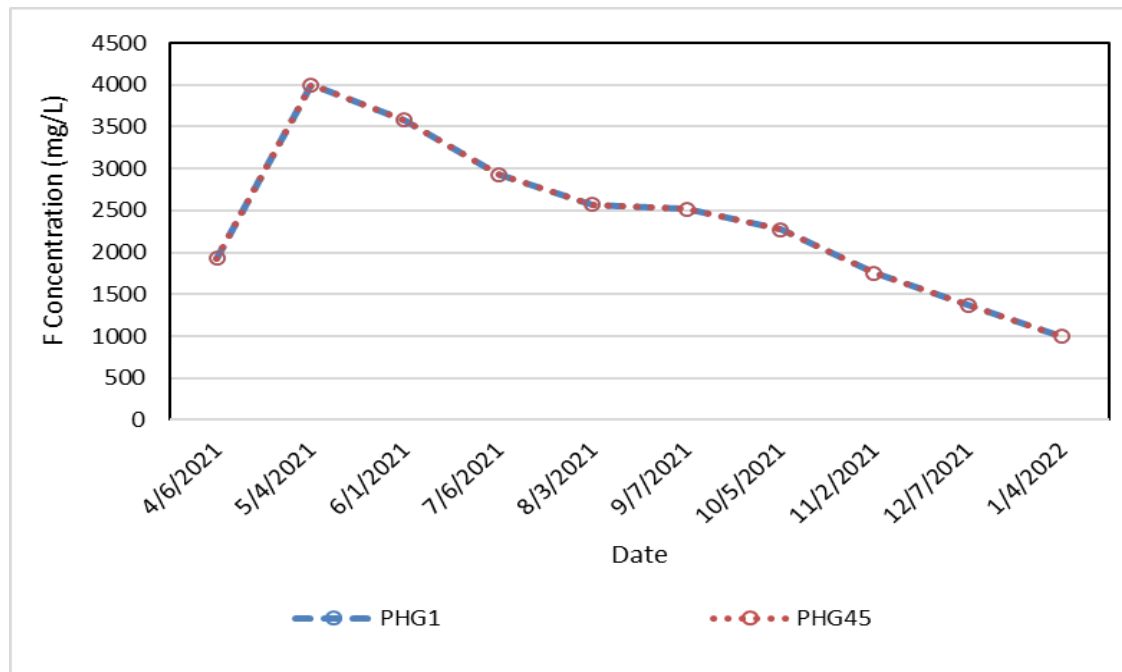












Appendix B

Barrel Leach Instructions

AMMAROO PHOSPHATE BARREL LEACHATE TESTS

Aim

The aim of these barrel leachate tests is to simulate the long-term effects of rain soaking through the various materials that will be piled above the surface or disposed of in pits at Ammaroo Phosphate Mine and to determine what, if any, potentially deleterious elements might dissolve and that could potentially escape into the environment as water soaks through the stockpiles. In addition, the supernatant sitting above tailings in a tailings disposal facility is being simulated.

This document and its appendices provide sufficient detail for someone else to replicate the set-up and to undertake the routine monitoring and sampling required. The equipment is set-up at Shed 19, Coconut Gove Industrial Village, 8 Tang Street, Coconut Grove.

Introduction

There are six 100 L (litre) barrels with either 120 kg or 90 kg of samples in each. These simulate stockpiles of:

- Unsorted ore (120 kg)
- Overburden with no iron (Fe) (120 kg)
- Overburden with high Fe (120 kg)
- A second overburden with high Fe (120 kg)
- Top soil and surface sand (120 kg)
- Tailings produced by COREM in Canada (90 kg)

The first five barrels were set-up on 12/04/2018 and the first leachate extracted on 01/05/2018. The tailings barrel was set-up later and treated differently.

The most important element of the Verdant Minerals barrel leachate tests is that all fine-grained material is included, as it would be on the actual stockpile. Many other barrel leachate tests and the bench-scale AMIRA-standard sieve the sample and exclude fines.

For the purposes of this study 'ore' is defined as $>10\% \text{ P}_2\text{O}_5$ and $<5\% \text{ Fe}_2\text{O}_3$. Two samples with high Fe were used because it was felt that ironstone would be the lithology most likely to leach metals. The first four barrels contain representative samples of drill core, selected to compensate for the various portions of core available (from $\frac{1}{4}$ to full core) and broken in such a way as to reflect the competency of the rock and hence the likely size of material on the stockpile. The soil/sand sample is exactly as at the surface and contains organic matter as would be on a stockpile of material put aside for rehabilitation. The tailings sample was produced by COREM in Canada. The particle size distribution was not quantified, but by observation there is a considerable proportion of clay-sized fraction.

Given the low rainfall on site, it would be impractical to simulate the actual annual rainfall or even the most intense events. Instead, the rainfall is greatly accelerated by the addition of a large quantity of water to each sample each month. Since the barrels are effectively walled cylinders, we are only simulating what would soak through a stockpile not what would run off. Run-off would have a much shorter time in contact with the material on the stockpile and run-off would also physically carry material off the pile. Such material is not leachate. At the lab, the samples are filtered to 0.45 micron to exclude any physically transported material, since we are only interested in chemically transported material in the leachate. The first five barrels contain sufficient water that about the lower 30% -50% of the sample is permanently saturated. This is unrealistic since a surface stockpile or dry material disposed of in a pit would not be below the watertable. However, permanently-saturated wet in-pit disposal of tailings is also being simulated.

Each week a small amount of the liquid leachate that has soaked through the sample is taken from the tap at the bottom of each barrel and tested for temperature, pH, conductivity and oxidation/reduction potential with a calibrated meter. The supernatant above the tailings is also tested. In addition, **each month** as much liquid as will naturally flow out is collected from the bottom drain tap and sent to the lab for analysis. **For all but the tailings, an exactly equivalent amount of RO water from the lab (make-up water) is added to replace what**

was removed. The lab supplies very pure make-up water produced by reverse osmosis (RO). They can only produce 25 L to 30 L per day for use by themselves and all their clients and this was a factor in determining the scale of these tests and the frequency of sampling. A theoretical maximum amount of 13 L to extract and replace each month was determined by Rob Virtue at GHD to simulate a nominal rainfall event of 100 mm (not 100 ml) over the barrel interior surface area of 1,280 cm². In reality, normally between 2 and 10 L is collected. The amount from each barrel should be about the same from month to month. Our tests do not use a roster of different volumes of make-up water since such tests are designed to simulate alternating different levels of exposure and inundation of material that is susceptible to acid generation which our stockpile material is not. The blue RO containers are numbered and should be used in numerical order to ensure that RO water sits in each container for roughly the same period.

The tailings sample is treated differently to the other five barrels. Its barrel could only be set-up on 25/10/2018 when the tailings sample arrived from COREM in Canada. This was much later than the others. Only 90 kg of dry tailings could be used since that filled the barrel. The barrel was then filled to the brim with 57 L of RO water necessary to establish full saturation initially. **This barrel must be kept brim full to simulate fully saturated tailings and supernatant.** Any liquid that comes out of the bottom tap will be as per the other five barrels and simulating what could potentially escape underground from an unlined tailings disposal. The supernatant liquid sitting above the tailings would be similar to what would be on the surface of a tailings dam. Unfortunately, the tailings supplied by COREM were ground too finely to sustain the gravity-driven pervasive infiltration needed for column barrel leachate and are theoretically fine enough to pass through the geotextile filter, so flow from the bottom tap could eventually cease, both because of lack of infiltration, and because the void at the bottom of the barrel will silt-up. In anticipation of this, the barrel will be both top and bottom sampled until flow from the tap ceases. The sample from the tap is labelled with the suffix B for bottom and the first leachate was extracted on 06/11/2018. Top-supernatant samples are suffixed T. If the flow from the bottom tap ceases, the tailings test will be swapped to top only. These tailings liquid samples can be turbid and it is imperative that they are filtered to 0.45 micron at the laboratory. The tailings tests will initially be conducted on the same schedule as the other barrels, ie weekly meter readings and monthly sampling, but this could change depending on results. The bottom sampled liquid has become anoxic, reducing and foul-smelling (very different to all other samples). This is probably due to bacterial activity. It is especially important to avoid contaminating / inoculating the other drums and to avoid contact with the liquid or breathing its vapour.

Normally, barrel leachate tests are run for a minimum of a year and routinely for two years or more; some up to 10 years. In our case, we are aiming for a minimum of 24 to 30 monthly samples, depending on the results.

It is stressed throughout these instructions that cross-contamination must be avoided and all meter electrodes, measuring cylinders, measuring jugs, funnels etc that come into contact with the leachate must be cleaned by rinsing with purified water after each use and stored upside down to prevent dust settling in them. Lab-supplied RO water, distilled, deionised or demineralised water available from the supermarket are all suitable for rinsing and adequate supplies must be maintained at the shed. Under no circumstances can anything other than lab-supplied RO water be used as make-up water to add to the barrels.

Preparatory Analyses

Prior to the actual leachate tests, representative samples (nominally 1 kg) of the dry solid contents of each barrel were analysed blind for the same suite of elements as the leachate. ASLP (Australian Standard Leaching Procedure) was performed as per the standard, ie after crushing and screening to <5 mm. Grinding and milling (85% passing 75 micron) was done prior to four-acid digest (near total digest) and ICP.

The lab provided an analysis “blank” of the RO make-up water that they are supplying to show that all elements were below their levels of detection. Another sample (rinse water) was taken of the make-up water after it had been sitting in the apparatus without any sample and in the sample transport container. This was to test if any contamination was coming from the equipment. Some low levels of metals were detected leaching from the green barrel, green jerry cans and blue water containers, despite all these being rated for drinking water. Some metals (Cu, Zn) may be from the colouring agent used and some (Sb) might be from the mould-release.

Weekly Meter Readings

Weekly meter readings are required until the variability and change between readings has been sufficiently quantified. In order to synchronise with the monthly tests, the weekly meter readings should be **done on TUESDAYS**. Instructions for the use and calibration of the Horiba meter are appended. The meter takes two AA batteries which should be removed from the meter if it is unused for longer than a month. However, **note that the meter loses its calibration if the batteries go flat or are removed**. If stored correctly between uses, the calibrations of the meter and its electrodes should last for the three months before routine calibrations are due again. Since the calibrations are based on 25°C, they are best done in the office. There is a calibration log book in the meter box. We have a back-up meter and spare electrodes in the office. There are spare lithium batteries in the office.

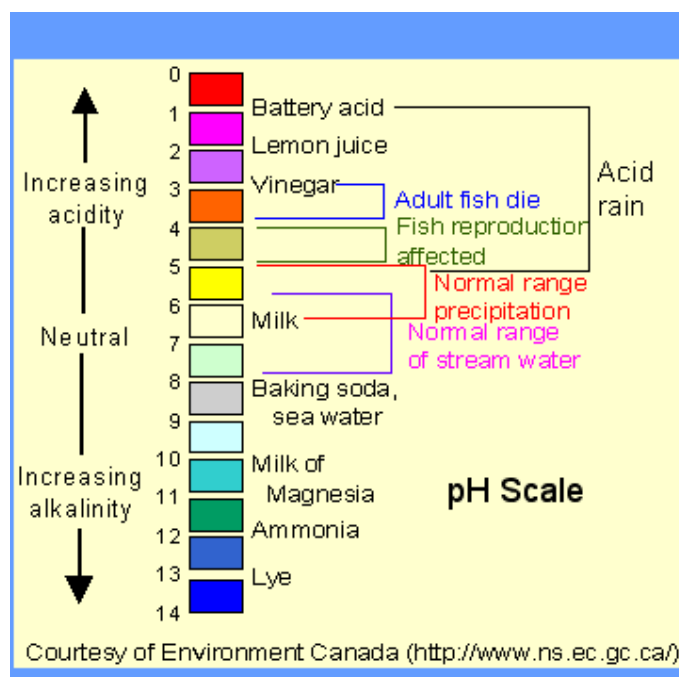
It is important to avoid cross contamination of samples or contamination of the electrode storage solutions when swapping electrodes. Always rinse the electrode in distilled water and wipe clean. At the end of each Tuesday's readings, replace the electrode storage liquid with new distilled water.

Note that the pH and ORP use the number 1 jacks on the meter and conductivity uses number 2 and the meter has to be set to the appropriate measurement mode and jack inputs using the Mode button. Ensure that both cables are securely connected to the appropriate jacks for each reading and that the meter is in the correct mode and the Measure button has been pushed. The ORP reading can be either positive or negative. If the temperature reads 25°C exactly, it probably means that the smaller jack is not connected properly. If the reading differs significantly from that of the week before, check the connections, restart the meter, check the mode, and re-do the measurement. In a few cases, the meter can take several minutes to stabilise on a reading. This is particularly so for pH and ORP. It will beep when it is ready.

pH

The Horiba pH electrode contains a concentrated solution of KCl (Horiba solution no. 525-3) and has been calibrated against pH 4.0 and pH 7.0 standard solutions. Before use, check that the electrode is nearly full of fluid. If not, we have replacement KCl in the office. Note that this solution has to be routinely replaced every three months and the meter recalibrated (see Appendix 3 for meter instructions). The solution also has a shelf life of less than a year even in an unopened bottle at 25°C. The pH electrode has a slide on its handle which covers a small port that has to be open for readings and closed for storage. Do not immerse the electrode in too deep a sample or rinse water where those could enter the port and contaminate the KCl. Forgetting to close the slide between uses will mean that the electrode dries out and deteriorates rapidly. To take a pH reading, place a small amount from the tap on the barrel in a measuring cylinder (from 3 cm to 5 cm deep is needed for a pH reading) and measure the pH with the cleaned, rinsed (in distilled water) and dried (with a paper towel) electrode and calibrated meter. pH is temperature dependent and the meter will compensate, but it is important to record the actual temperature shown on the Horiba meter. **It could take several minutes for the pH reading to stabilise**. Record the barrel sample number, temperature, pH to the number of decimal places displayed on the meter, the time and date in the log book. Remove and clean the pH electrode and measuring cylinder in distilled water and dry with paper towel before the next measurement. After a successful reading, discard the sample in the measuring cylinder and rinse the measuring cylinder in distilled or RO water before moving to the next barrel.

The pH scale goes from 0 to 14. A low pH is acid and high is alkaline. Unpolluted rain has a pH of 5.6 to 6.5 after absorbing CO₂ from the atmosphere, but has almost no buffering capacity so is highly subject to change. We should have make-up water that is near neutral 7.0 but see the comment below about allowing RO water to equilibrate. Note that our meters are measuring relative to the USA standard pH scale (not NIST).



Conductivity

The conductivity electrode has been calibrated against a 1,413 uS/cm standard solution. Use port 2 and switch the meter to the conductivity electrode which has been cleaned and rinsed in distilled water and wiped dry. Take a sample in a measuring cylinder of sufficient depth to cover all three black rings on the electrode. Record conductivity, temperature, time and date in the log book. Clean the electrode and measuring cylinder between samples. Between uses, store the conductivity electrode in its container / cap filled with distilled or demineralised water. Do not let this electrode dry out. The meter reads in either uS/cm or mS/cm and will automatically default between these two scales, so be sure that the correct reading and relative scale are recorded.

ORP

ORP is oxidation/reduction potential. The Horiba ORP electrode is the one with a black or grey ring on the handle and connects to the same port (1) as, and in place of, the pH electrode. The handle ring contains a rubber-covered filling hole. The ORP electrode is filled with the same 3.33M KCl solution as the pH electrode. Before use, check that the electrode is nearly full of fluid. If not, we have replacement KCl in the office. Note that this solution has to be routinely replaced every three months. The Horiba D-54 meter does not have an ORP calibration function. To check if the ORP setup is working, you need to test it in a 240 mV ORP standard solution. If the meter reads the standard solution within +/-10% of the correct value at 25°C, then the ORP electrode is working correctly. This standard solution has a longer shelf life than the others and ours will expire in 2022. The meter is set up to read ORP in USA units. Take a sample of 3 cm to 5 cm depth in a measuring cylinder and after the electrode has been cleaned and rinsed in distilled water and wiped dry, open the rubber port on the handle and take a reading of ORP, temperature and record with time and date in the log book. Clean the electrode and measuring cylinder between samples. Between uses, remember to close the port in the handle and replace the protective cap to keep the electrode wet with distilled water. If the brown colour of silver chloride is detected inside the electrode, the internal KCl solution must be replaced immediately.

ORP readings can be positive or negative.

Note that the meter will accept the ORP and Conductivity electrodes together in Ports 1 and 2 respectively.

Monthly Measurements and Sampling

RO Water Equilibration

Verdant has two sets of dedicated labelled 20 L sample jerries for each leachate barrel (12 x 20 L in total) and we rotate them at the lab. We also use two sets of 25 L water containers for RO make-up water and we rotate

them too. The RO water drums are numbered. Use them in numerical order. **Do not lift or carry the 25 L drums by the tap.**

The tailings top sample is put in a disposable 500 ml plastic bottle supplied by the lab.

On arriving at the shed for sampling, the first thing to do is loosen the tops from at least two 25 L containers of RO water. This water needs to be exposed to the atmosphere for at least an hour for the pH to equilibrate and its pH rise from about 5.5 to nearer 7.0. The wide-mouth containers enable better exposure. Even so, the longer the exposure, the better. However, do not let any dust or contamination into the open container.

Meter Readings

While waiting for the RO water to equilibrate, the same routine meter readings as described above need to be done and the data recorded. Be especially vigilant about pH because the values recorded in the shed will be compared to those when the samples are received in the lab. This is to quantify any changes that might have occurred in transit or where the time between sampling and pH measurement at the lab exceeds guidelines.

Sample Collection

In order not to conflict with the large amount of samples at Intertek from Arafura and McArthur River Mines, Verdant samples have to be taken to Intertek on the **FIRST TUESDAY of each month.**

The sample jerry cans have been cleaned and rinsed at the lab, but check that there is no residual liquid in them. Be sure to use the correct labelled jerry can for its corresponding barrel. Take a sample to a maximum of 13 L from the tap on the first 100 L barrel using the measuring jug to get one litre at a time and transfer into the corresponding green sample jerry can. A funnel will be needed in the jerry can opening to avoid spillage. To avoid losing count, write down a check list. If you do lose count, weigh the jerry can and contents compared to an empty jerry to determine how many litres are in there. The sample number and number of litres for each jerry can is to be handwritten on a piece of A4 paper and put in the pouch on the side of the jerry can. Remember to remove any sample numbers that are there from the previous round. All sample numbers are prefixed with date in the format 2018_04_25. This is followed without a space by either:

- OR for ore
- BO for overburden no Fe
- BF1 for overburden high Fe barrel 1
- BF2 for overburden high Fe barrel 2
- TS for top soil/sand
- TLB for tailings bottom.

In the likely event that there isn't 13 L available to drain from the barrel, carefully measure and record how much there was available. Never attempt to tilt the barrel. After the leachate sample has been removed and safety sealed in the green jerry can, using a one litre measure, top up the first five barrels listed above with EXACTLY the same amount of RO water as the leachate that was removed. Be particularly gentle when tipping make-up water onto the samples. We are simulating rain. Wet the entire surface and try to avoid the water channelling down the inside wall of the barrel. Again use a checklist to ensure you get the count correct.

The tailings top sample, suffixed TLT, is put in a disposable 500 ml plastic bottle supplied by the lab and the tailings barrel (and only it) is topped up to the brim with RO water.

Blanks of RO Water

500 ml blanks of RO water taken from the same drum (Drum 8) were collected and analysed on 07/05/2019 and whenever this drum was rotated into use or at nominal three monthly intervals, whichever comes first. The results can be compared through time and with the results of the lab-supplied blank and the initial rinse water done at project set-up. Note that the RO water from Drum 8 contained measurable amounts of B, Cu and Zn, presumably as contamination from the plastic drum.

Sample Collection, Dispatch and Chain of Custody

It is desirable for all meter readings and sample collection to be done at as close as possible to the same temperatures each time, so this is being undertaken pre-dawn before the shed heats up.

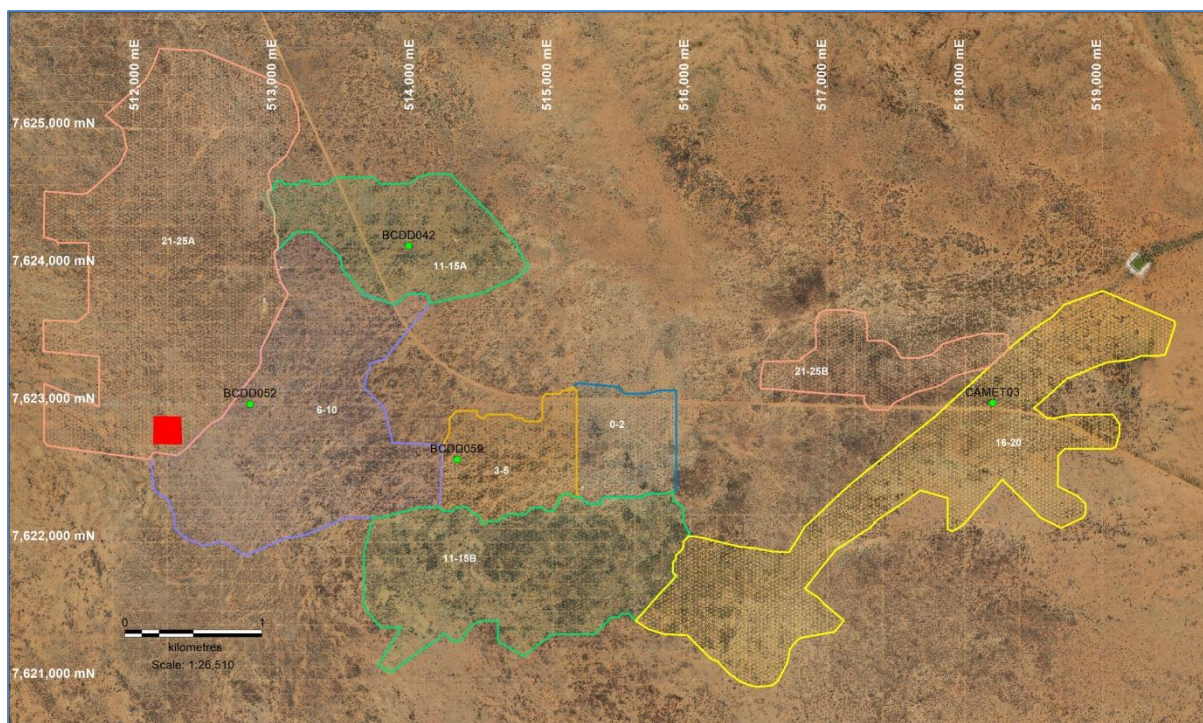
Once all samples are taken and labelled, fill out the accompanying Chain of Custody form and drive the samples to Intertek (55 Export Drive, East Arm). All barrel leachate work uses Verdant Purchase Order 101 and this is already filled out on the form. Be sure to record the exact time that each sample was taken on the Chain of Custody form. Remember to take back the empty RO water containers to be refilled. You will need a ute to carry six 20 L jerries and up to two or three empty 25 L circular drums. Be sure that they are all safely secured in the vehicle; at least tied down through the handles. Temperature changes to the leachate during transport could affect the results and, although this is ameliorated by the relatively large volume, it is imperative that the samples arrive as quickly as possible and with sufficient time for the lab to expeditiously do the necessary sample splits and refrigerate those splits before they are swamped with other daily work. To date, usual practice has been to have the samples to the lab when it opens at 8:30am. If the samples are received too long after collection, the lab will report a “holding breach”.

There is a side door on the driveway to the right of the building about 10 m from the front. Take the containers through there and put them on the trolley or floor as instructed by Intertek staff. Do not take containers to the front counter unless asked to do so. Before leaving the lab, collect the empty sample jerry cans and full RO water containers from the previous rotation.

Appendix 1 – Sample Distribution

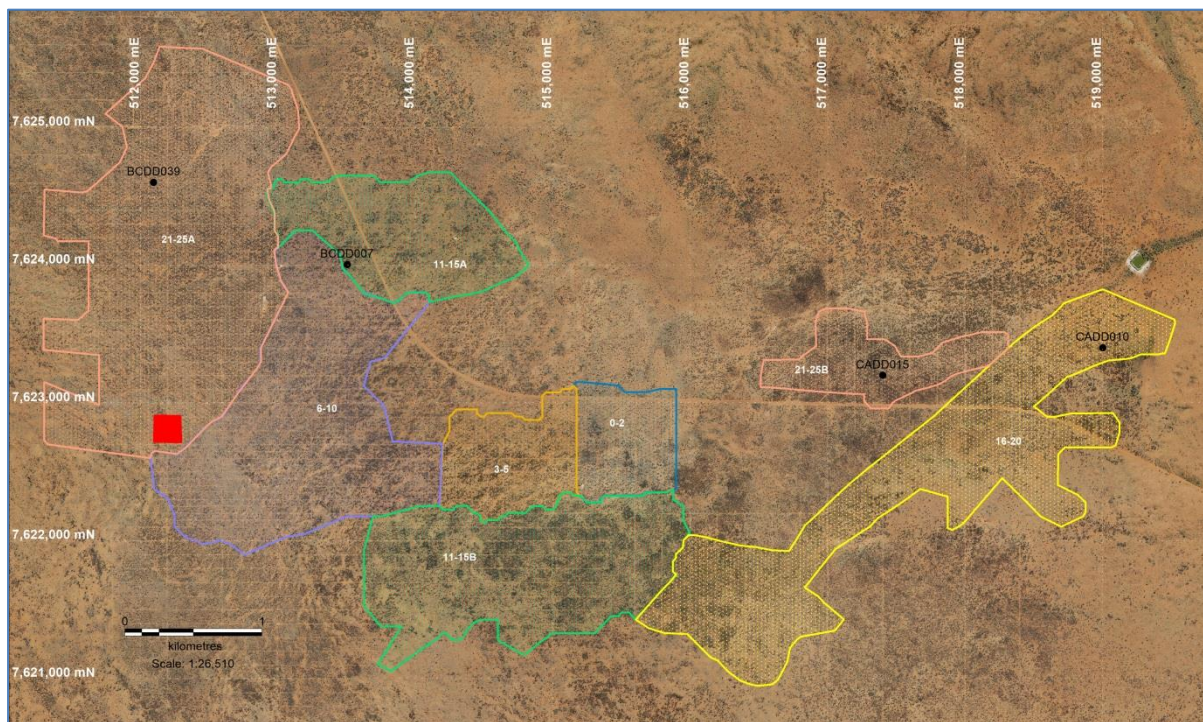
Ore - OR

For the purposes of this study 'ore' is defined as $>10\% \text{P}_2\text{O}_5$ and $<5\% \text{Fe}_2\text{O}_3$. Ore samples came from four diamond drillholes as shown below. There was only a limited amount of ore core left to use.



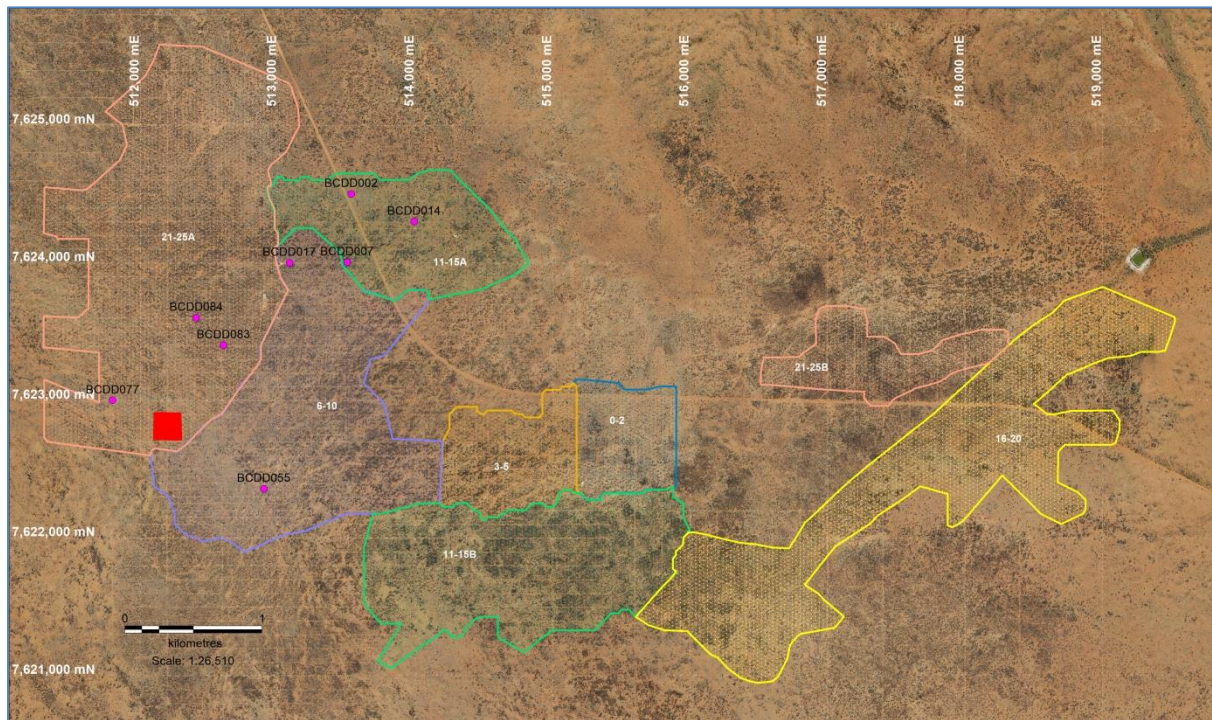
Overburden no Fe - BO

Low Fe overburden came from four diamond drillholes as shown below.



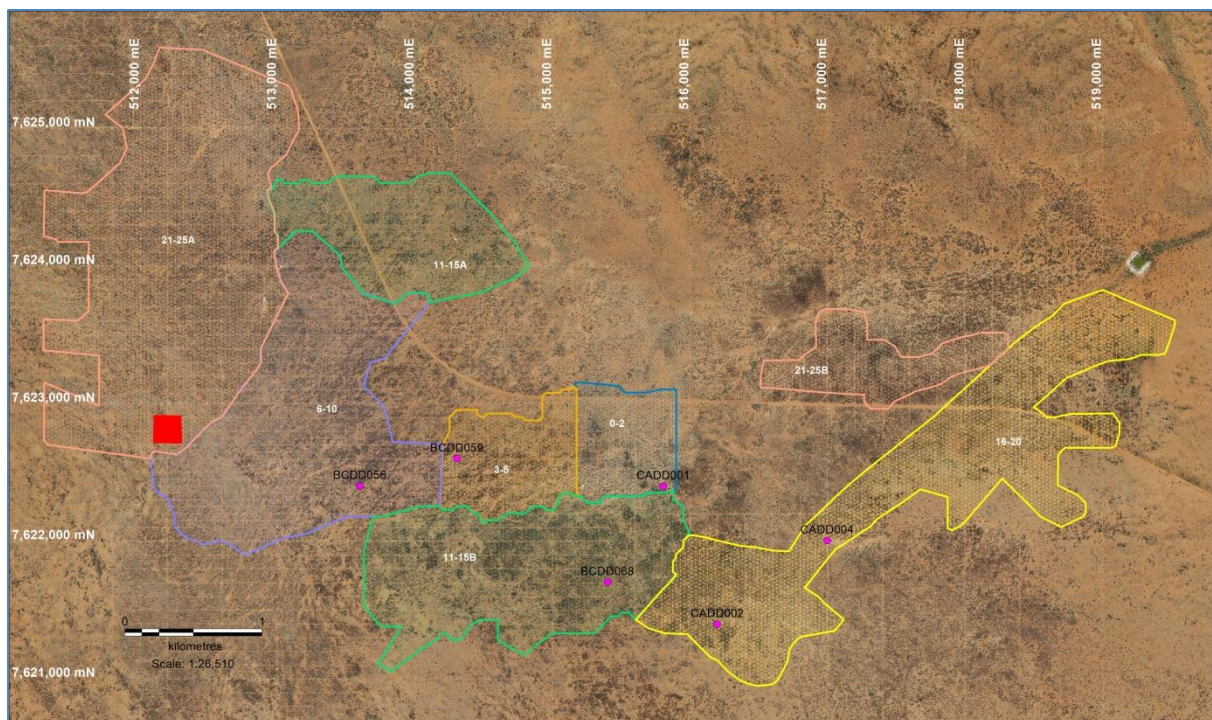
Overburden High Fe - BF1

The northwest population of high Fe overburden came from eight diamond drillholes.



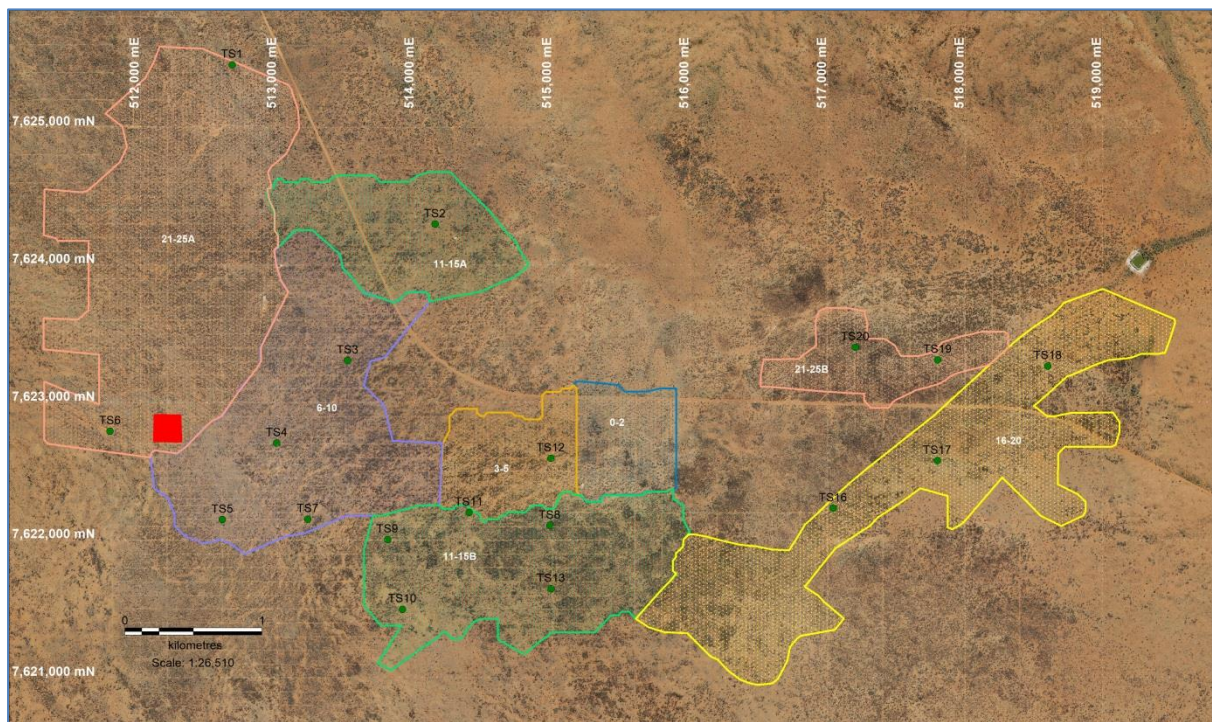
Overburden High Fe - BF2

The southeast population of high Fe samples came from six diamond drillholes as shown below.



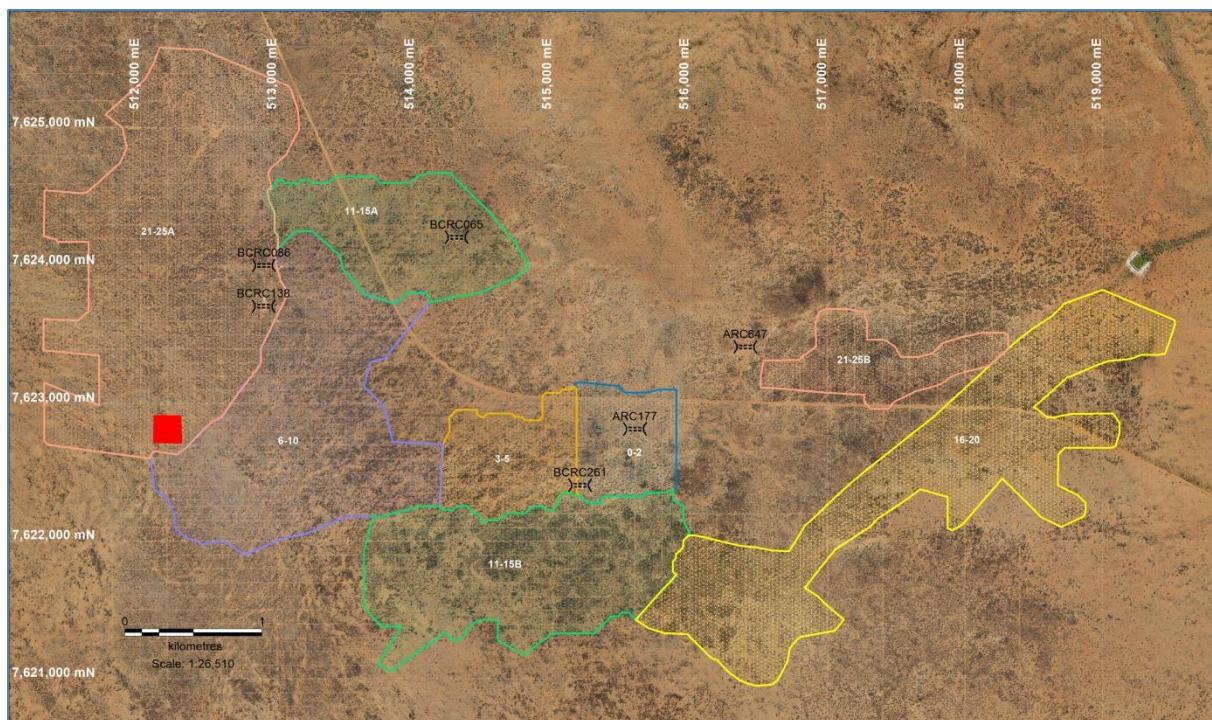
Top Soil - TS

Representative top soil/sand samples came from 18 locations spread across the 25-year mine plan.



Tailings - TL

Ore material described as “average Fe in ore” and “above average Fe in ore” from the six costeans shown below and was used by COREM in Canada to make tailings. The labels are the drillholes that were used to site the costeans. The maximum sample depth from the costeans was 7 m with most material coming from 4 m to 5 m depth.



Appendix 2 – Equipment

Specifications

Unlike AMIRA-standard bench-scale tests, there is no standard equipment set-up for barrel leachate tests and the choice of equipment and the scale has to reflect the nature and quantity of the sample and make-up water volume. The equipment used has to be laboratory-grade or at least food-grade and selected to avoid any metals, colours, UV stabilisers or other chemicals that could leach over the duration of the tests and contaminate the results. The equipment used here largely follows recommendations and procedures from Rob Virtue at GHD.

The 100 L HDPE tanks (herein called barrels) and their accessory stands were manufactured by Maze Products (<https://www.mazeproducts.com.au>) and are sold as “mini-tanks” designed for domestic water storage. There is 5,350 ml of dead space below the level of the tap ie water that can never be extracted (this volume will also be a sump for any silt that gets through the geotextile). The internal cross-sectional area allowing for the curves is approximately 1,280 cm².

Geofabrics supplied the geotextile (Bidum <https://www.geofabrics.co/products/bidim-nonwoven-geotextiles>). Note that the roll Verdant had was only 59 cm wide which necessitated overlapping two layers to get the width required. Bidum floats even when saturated. Geofabrics also supplied geomesh (Versicell). Verdant weight-tested four layers of cut geomesh to 120 kg over approximately 200 cm² without crushing. However, since Versicell is designed square, cutting it into a curve compromises the strength at the edges. Note that Versicell floats.

Water and sample containers were from Icon Plastics. Samples were taken to the lab in green heavy duty “army” water jerry cans. RO water was transported in blue 25 L round wide-mouth water containers. Duplicate sets of each were rotated so one set could be left at the lab. Taps were also from Icon Plastics.

Gutter guard 180 mm wide made by Whites (www.whitesgroup.com.au) was used to hold the geotextile against the inner wall of the barrel. Whites confirmed that although this product is made from recycled plastic and has UV stabilisers, it is rated as “drinking water safe”.

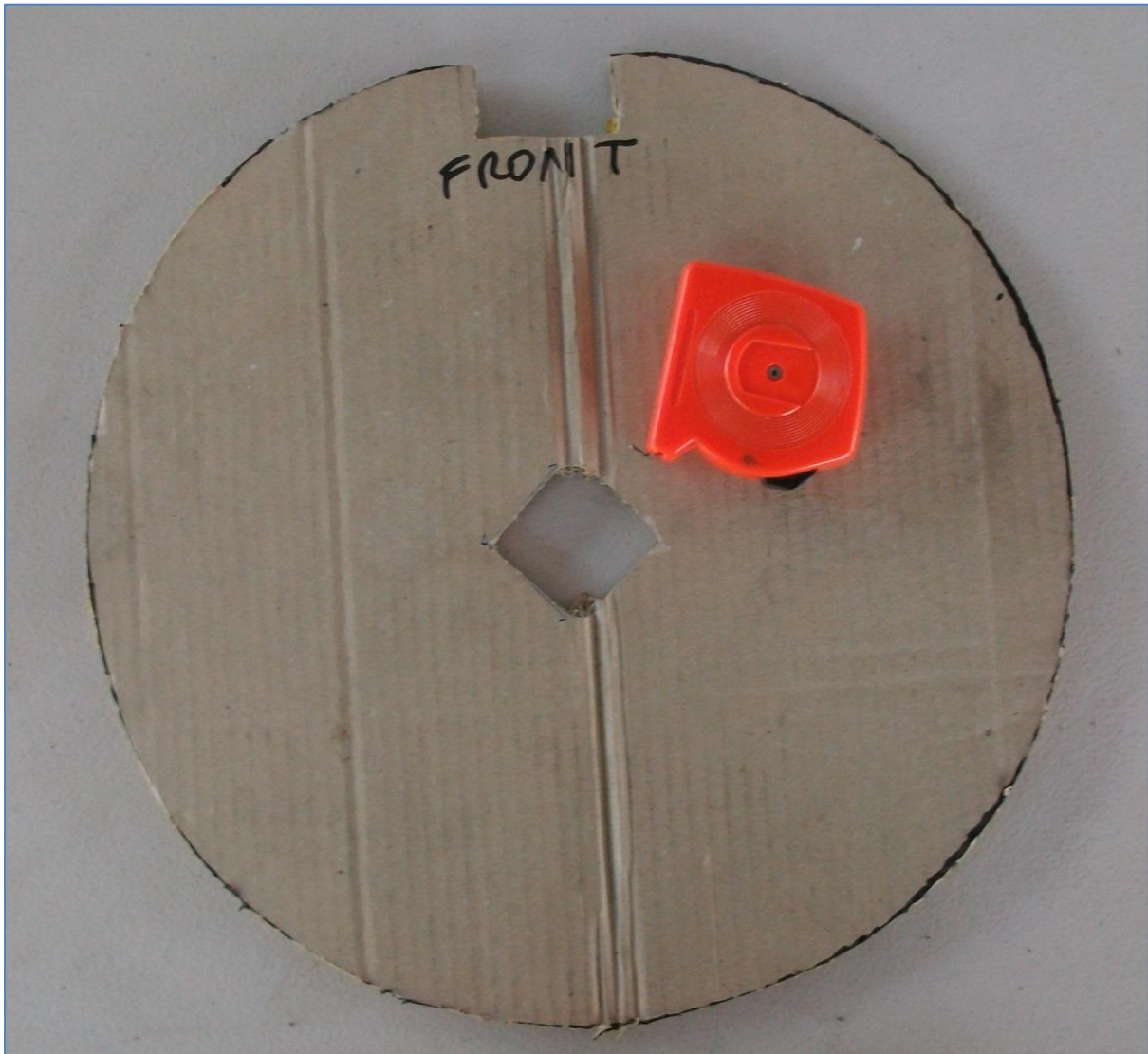
Construction and Set-Up

The set-up uses three lower layers of stacked geomesh cut to a reasonably tight fit in the barrel. These are overlain by a layer of geotextile cut oversize so it extends up the inside of the barrel and held in place by a tight-fitting overlying layer of geomesh and a ring of gutter guard.

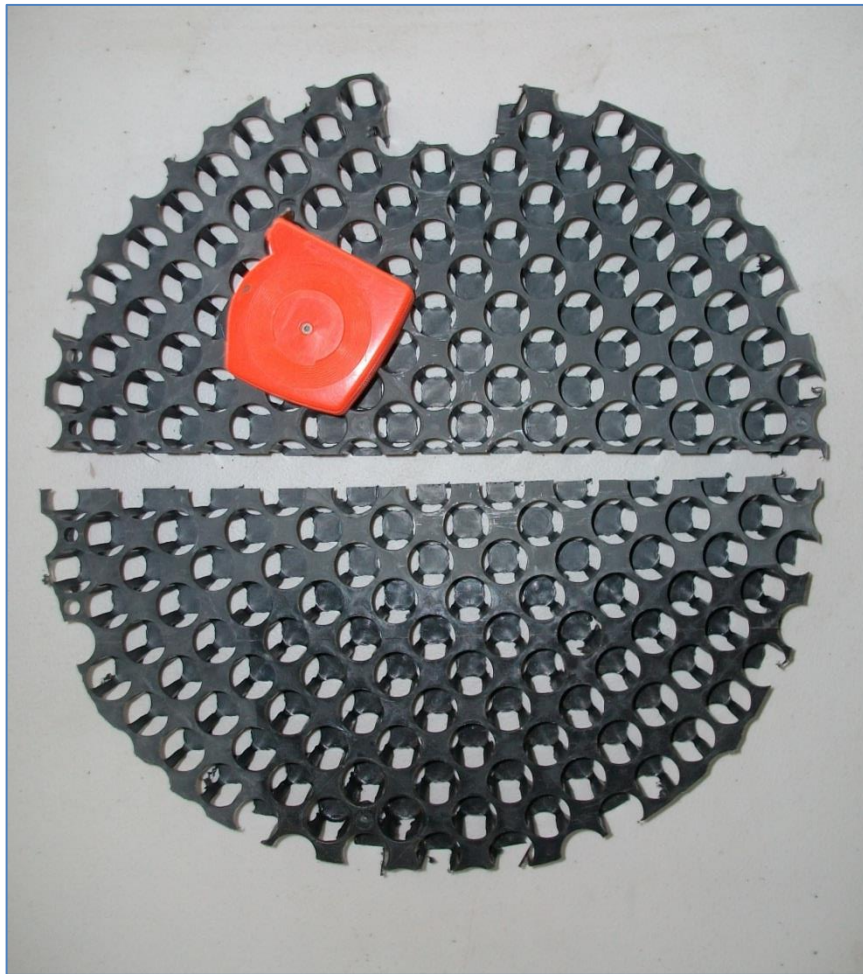
The lower three-layer geomesh supports were cut to a template made by using the bottom of the barrel as a guide. Each layer has to be in two parts to be able to fit through the barrel opening. A cut-out was made to allow clearance for the tap mounting that protrudes into the barrel. Each layer was individually try-fitted and trimmed as needed.

The offset holes in the geomesh and the spacing of the supports between its top and bottom layers, make the Versicell geomesh quite difficult to saw. After considerable experimentation, it was found that a 450 W electronic-speed controlled jigsaw with a Powerfit 100.4 mm long 20 TPI vented high carbon steel blade operating on medium-high speed was best able to cut the geomesh. Any thinner blades broke or bent and any thicker were unable to cut the curve. Too few teeth per inch or too high cutting speed bogged the blade and/or melted the plastic. Even the optimal jigsaw set-up left behind burrs that were cut off with side-cutters.

Once the lower three layers of geomesh were in place in the barrel, offcuts of the geotextile were stuffed into the small annulus between the geomesh and the inner barrel wall.

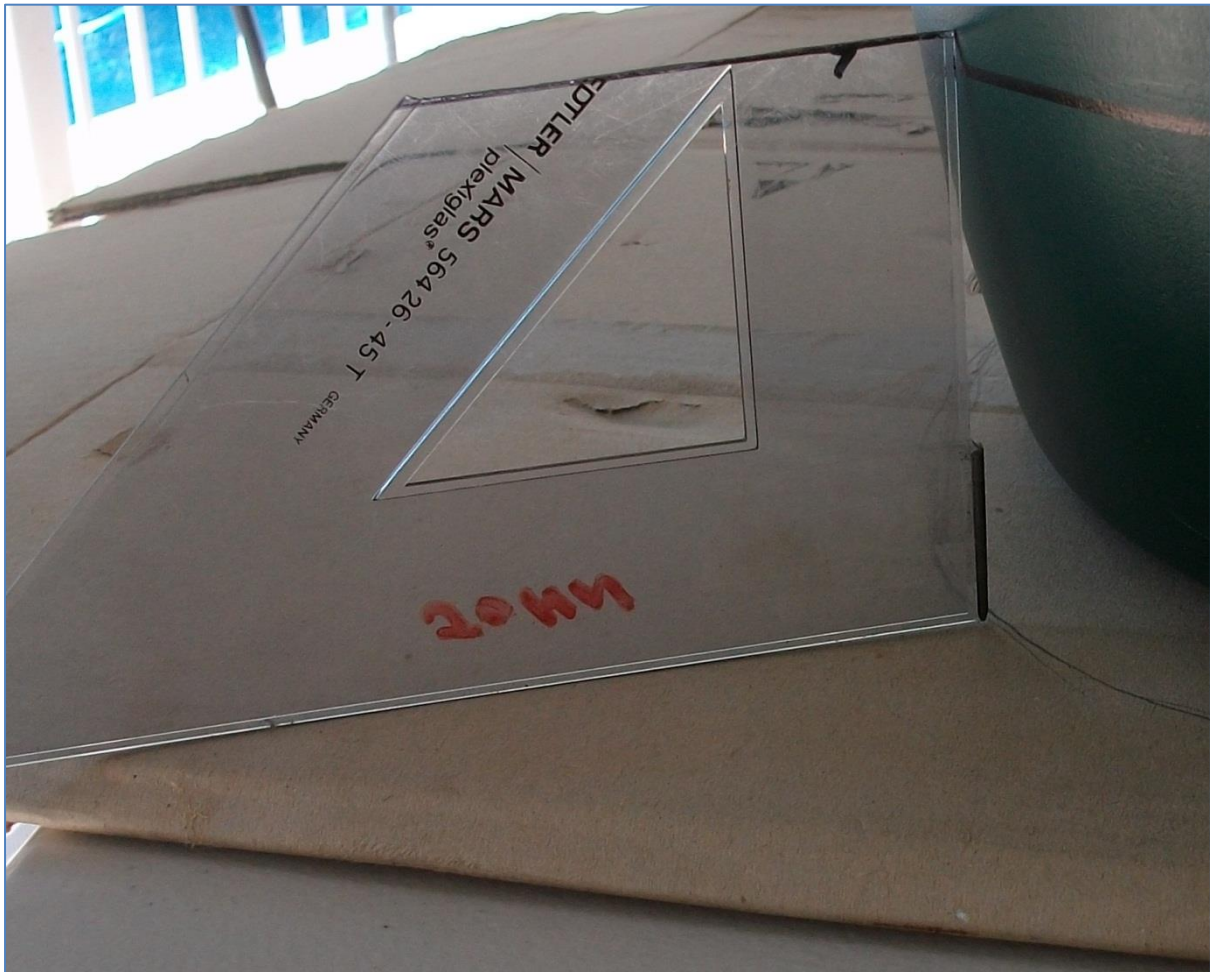


Template for the bottom three layers of geomesh. Note the cut-out for the tap marked "front". The central square cut-out was to grip the template to extract it from the barrel. That cut-out is not required in the actual geomesh. Also note the the barrel is closer to circular towards the base, so the annulus between each of the stacked geomesh layers and the barrel inner wall will be slightly different.



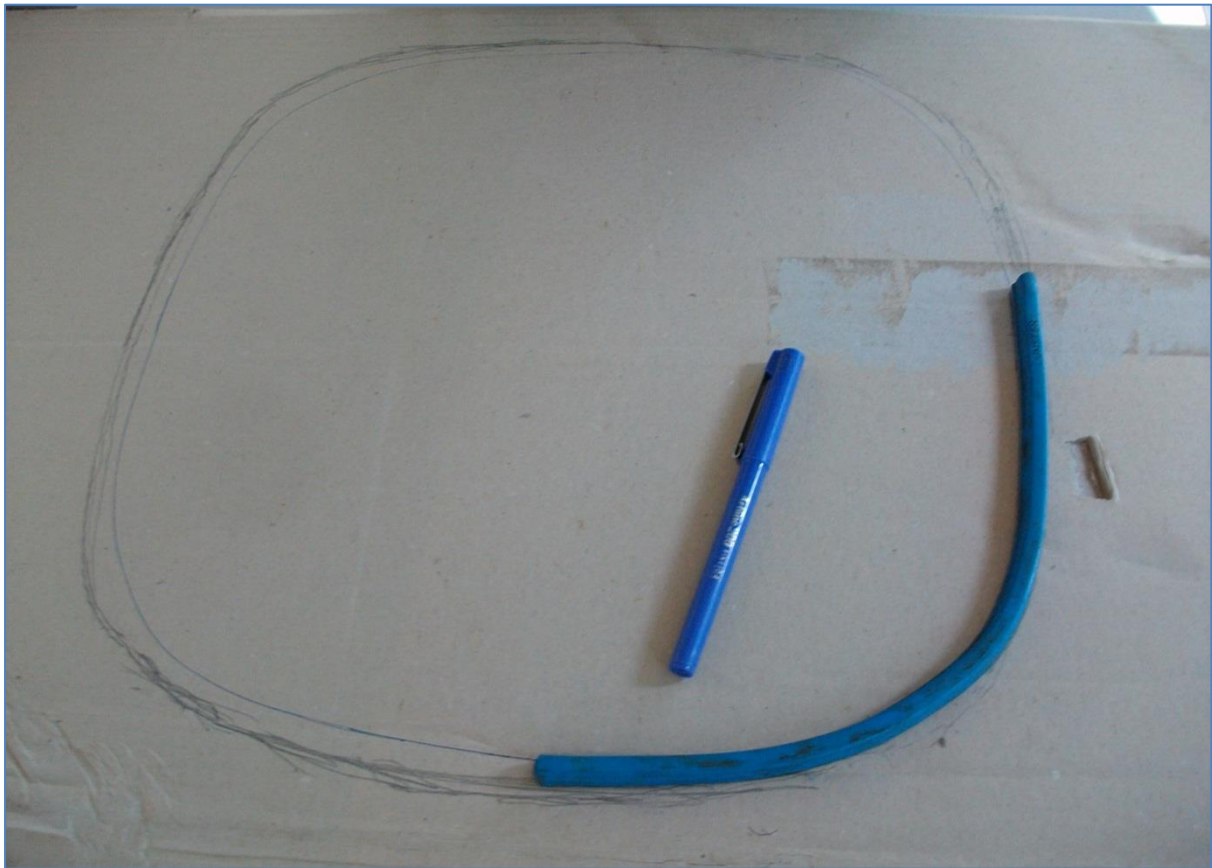
An example of a raw-cut geomesh layer which is one of three in each barrel. The base of the tape measure is 6.5 cm across for scale.

The uppermost geomesh layer has to be a snug fit in the barrel and sit horizontally just above the level of the tap, nominally 9 cm up from the inside base of the barrel. This height is based on three thicknesses of geomesh under the geotextile. At 9 cm to 10 cm above its base, the barrel has a complex curved internal shape, smaller than the internal shape of the rest of the barrel. A multi-step process was undertaken to determine the precise outline required for the upper geomesh. A cut-down setsquare with a pencil lead attached was used as a right-angle with a 10 cm height to trace around the outside of the barrel onto a sheet of cardboard.



Scribing the outside diameter of the barrel onto cardboard. The cut-down setsquare is just over 10 cm high to allow for the thickness of the bottom of the barrel. The black line on the barrel marks where the base of the geogrid will sit inside.

A flexible curve (used in drafting) was used to better model the curve and the flexible curve was rotated to scribe each corner identically. Tracing onto the cardboard around the inside of the flexible curve allowed for the thickness of the barrel wall and the geotextile. Note that whereas the barrel was closer to circular near the base, the cross-section is more of a square with rounded corners at the height of the top geomesh layer.



Using a flexible drafting curve to model the inside outline for the template.

The cardboard was then cut with a box-cutter knife to make a template for the geomesh. Since the upper geomesh plate will be substantially bigger than the opening at the top of the barrel, it had to be made in two parts. Thus, the cardboard template was folded in half and the edges trimmed to be exact mirror images. A handling square was cut in the centre of the cardboard template. As shown below, this template for the geomesh, nominally 10 cm from the base of the barrel, is smaller than the cross-sectional area used to calculate the make-up volumes but larger than the layers of geomesh below it in the barrel.



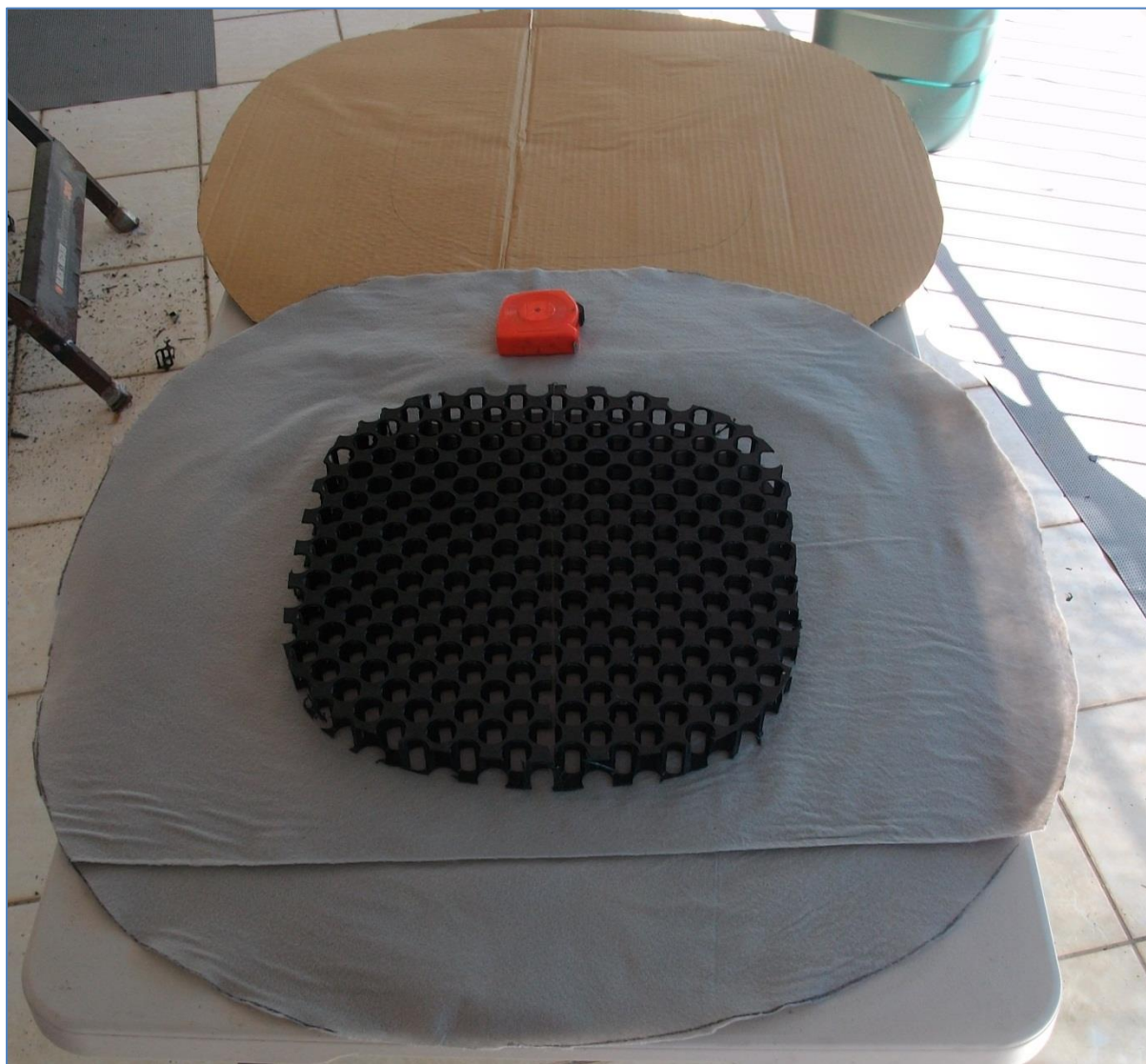
Comparison of the template for the geomesh (with square hole) and the internal outline of the upper part of the barrel at the back (used to measure the cross-sectional area for calculation of the amount of make-up water). Note that the barrel changes profile more in one dimension than the other towards the top and bottom.

The folded template was then try-fitted and trimmed a minor amount as needed. Since the barrel is over 90 cm deep, a “grabber” was needed to manipulate the template using the centre square and a torch was necessary to be able to inspect the fit.



A “grabber” (on the right) and torch were needed to manipulate and try-fit the template.

Another cardboard template was made for the geotextile with 20 cm of overlap around the outside of upper geomesh layer. This allows for 18 cm that the geotextile will extend up the inside wall of the barrel held in place by a ring of gutter guard and nominally two centimetres of downturn back into the barrel. Since the geotextile is only 59 cm wide, two overlapping layers are required to get the required width.



Partially overlapping geotextile cut to cardboard template (rear) shown in relation to the upper-most layer of geomesh.



Mock-up of set-up for inside the barrel. Note the cut-outs for the tap in the lower three layers of geomesh, and the ring of gutter guard to hold the overlapping geotextile (two layers required to get the required width) against the barrel wall. The small annulus between the lower three layers of geomesh and the barrel wall was stuffed with geotextile off-cuts.

Rinse Water Sample

Once the equipment was in place in the base of the barrel, 13 L of RO water was added without any sample. This was allowed to sit in the barrel for 10 hours and then transferred to a sample jerry can where it sat a further 18 hours before arriving at the lab. This procedure was designed to test for any contamination from the barrel, the materials in it, handling equipment, RO water container or sample container. Zinc and antimony were found to be elevated.

Initial Test of Blue RO Water Containers

RO water that had been sitting in a new blue 25 L container for several days was analysed. Cu, Pb and Zn were found to be elevated. Also refer to the on-going blank RO water sampling described later.

Filling the Barrels with Sample

Composite samples were made to allow for $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ or full core. 120 kg of sample was put into each barrel. Solid pieces of core were broken in a subjective way that would reflect what would be going on the stockpiles. Any pieces of core over 30 mm were struck once with a geological hammer. If they broke, that's how they went in, if not, that's how they went in. Over half of the ore and overburden shattered with a single blow. Some held together and went in as chunks up to 7 cm long. Really competent lithologies like chert went in as is.

Adding Initial RO Water and Top Ups

Each of the first five barrels were setup, filled with sample and 13 L of RO water was added on 12/04/2018. No leachate had come through by 17/04/2108. A further 13 L of RO water was added on 19/04/2018. By 24/04/2017, no leachate had come through the ore or No2 overburden high Fe. A further 7 L of RO water was added to all barrels on 27/04/2018, making a total of 33 L or roughly one third the capacity of each barrel. The ore barrel had negligible flow on 22/05/2018, so an additional 2 L of RO water was added to each barrel, bringing the total to 35 L. Another 2 L was added to each barrel on 08/08/2018 because BF2 returned only 290 ml. A further 3 L was added to each of the first five barrels on 25/10/2018, taking the total in each of the first five barrels to 40 L.

The tailings barrel was set-up on 25/10/2018 after dried tailings were received from COREM in Canada. 90 kg of tailings was all that could be used since that filled the barrel brim full. Initially, 47 L of RO water were added, all on the same day as set-up to help bed-down the sample. The tailings barrel was then topped up to brim full so water could be seen above the level of the sample. The intention is to keep the tailings sample permanently saturated with liquid sitting above the tailings.



First five barrels on their stands.



First five barrels and their dedicated sample containers. A tailings barrel was added later.



Unsorted Ore.



Overburden No Fe.



Overburden High Fe No1.



Overburden High Fe No2.



Top soil / sand.



ghd.com

➔ The Power of Commitment

Appendix I

**Groundwater Science 2021 – Bore field
Testing and Design**

AMAROO PHOSPHATE PROJECT

Borefield Testing and Design



Document Title

Amaroo Phosphate Project Borefield Testing and Design

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1 Executive Summary

Verdant Minerals (VRM) are studying a development option for the Amaroo Phosphate project comprising a phosphoric acid plant. This results in increase groundwater use compared to the previously studied and approved, beneficiation plant. The projected groundwater demand increases from 3.6 GL/year for the beneficiation plant option, up to 10 GL/year for the Phosphoric Acid plant option.

To test the capacity of the target aquifer, and to establish the number and spacing of bores required to meet this demand, and a program of bore drilling and aquifer testing was undertaken.

Drilling comprised 3 pilot holes drilled at locations stepping out approximately 1km from the previously defined groundwater supply target. The most prospective pilot hole site WI08 was tested by airlift pumping and a large diameter test production bore was then installed. The bore construction comprised 323 mm steel casing to 114m depth, then 250mm open hole production zone to 168m depth. The target aquifer was the Chabalowe Formation in the Georgina Basin.

The pump test undertaken at the Amaroo Phosphate Project confirmed the very high transmissivity within the target aquifer at the site. The bore was pumped at 47 L/s for 7 days. Initial drawdown was 3.0m. Ongoing drawdown was 0.1m per log cycle.

The drawdowns at the observation wells were minimal, ranging from 0.05 – 0.06 m after 7 days pumping at 47 L/s. The high transmissivity values are typical of karst limestone aquifers, allowing for substantial flow rates in production bores.

The proposed borefield is comprised of 7 wells located 500 m apart located on the existing NW-SE oriented track. Bore spacing is conservative (High) to ensure bore interference effects are minimal. Seven production bores are anticipated to yield 50 L/sec each (or 11 GL/year total). One bore is included as contingency to allow bore and pump maintenance while maintaining the capacity to meet the water demand.

The capital cost estimate to install the borefield is \$2.5 Million with no contingency applied.

Operating costs will be power consumption at a total of 522 Kw. Maintenance allowance comprises complete pump replacement at 10 years at a cost of \$1.5 M. Daily borefield inspection is likely to be needed to ensure the borefield is operating as designed.

2 Introduction

2.1 Background

Verdant Minerals (VRM) are studying a development option for the Amaroo Phosphate project comprising a phosphoric acid plant. This results in increase groundwater use compared to the previously studied and approved, beneficiation plant.

A previous Feasibility Study was undertaken to evaluate the beneficiation plant option. As part of that study a water supply aquifer was identified and tested. A borefield was designed to supply 3.6 G/year, and EPA approval for that mine and water supply was obtained.

The projected groundwater demand increases from 3.6 GL/year for the beneficiation plant option, up to 10 GL/year for the Phosphoric Acid plant option.

This report presents the hydrogeological work undertaken to support the Definitive Feasibility Engineering Study for the larger water supply.

2.2 Context

The projected demand is 10 GL/year (320 L/s, 1,150 m³/hour).

The previous work to define the 3.6 GL/year supply comprised:

- regional scale review to identify aquifer targets in proximity to the project (GWS, April 2012)
- Three pilot drillholes to identify/confirm aquifer targets (GWS, May 2012)
- One test production bore yielding 25 L/s (GWS, Feb 2013, GWS Jan 2014)
- A long duration (7 day) pumping trial to determine aquifer properties. (GWS, Oct 2017)
- Groundwater Impact Assessment to Support Permitting of the previous Mine Plan (GWS, Oct 2017)

This work was adequate to give confidence that the 3.6 GL/year water demand could be met from a borefield comprising 3 bores spaced 500 m apart located at the WI03 investigation site.

The target aquifer is the Hagen Member of the Chabalowe Formation which infills the Georgina Basin. This is a regional scale aquifer system that extends many 100's of kilometres through the Northern Territory. The groundwater storage within this formation is immense, exceeding 160,000 GL. There is no uncertainty that the water is available to meet the project water demand. The only uncertainty is the yield and hence number of bores and CAPEX required to meet the demand.

A pumping test program has been undertaken to provide confidence to the DFS, that the 10 GL/year water demand can be met from a specific borefield design at the planned location for a defined cost.

2.3 Method

Three pilot holes were drilled at sites stepping out approximately 1km each from the previously defined groundwater supply at PB1. The results are summarised in Table 2.1. Two bores lost circulation during drilling and yield could not be determined. These bores were cased with 6 inch steel casing to serve as monitoring bores. Pilot hole WI08 yielded 2.2 L/s during airlift. Water level drawdown during airlift was measured with a pressure transducer. 0.2m drawdown equated to a transmissivity estimate exceeding 1000 m²/day, and the site was selected for production bore drilling.

Table 2.1: Drilling Results

HoleID	RN	x	y	Depth	SWL	Yield
WI06	41710	504354	7617886	90	76.4	Lost Circulation – No yield data
WI07	41660	504995	7618572	96	77.0	Lost Circulation
WI08	41711	503556	7617972	168	81.9	Airlift Yield 2.2 L/s for 0.2m drawdown
PB2	41712	503569	7617958	81.9	168	50 L/s

The production bore PB02 was drilled to 114m depth and cased with 323mm Steel casing. The production zone was then drilled 250mm diameter to 168m depth.

The plan was to conduct a constant rate pump test at the highest possible flow rate in production bore PB2, whilst monitoring water levels in PB2 itself and the 4 monitoring wells. To determine what flow rate would be sustainable, a step test was undertaken first. The step test indicated that the well could easily maintain the maximum possible flow rate achievable with the pump (~47 L/sec). The pumping test was then designed to run at the 47 L/sec for 7 days.

Data loggers were installed in each of the wells, and the plan was also to manually dip each well during the test. Recovery data was also to be recorded until each well had almost fully recovered.

Water quality parameters such as Electrical Conductivity (EC) and pH were also recorded during the test.

3 Pumping Tests

3.1 Pumping Test Details

The initial step-test began at 9am on the 21st of August 2020 and finished at 12pm on the same day. The final step was run at the maximum 47 L/sec and it was decided to run the constant rate test at that same flow rate.

The constant rate pump test in PB2 began at 1pm on the 21st of August 2020 with the water level fully recovered from the step-test by this time. The flow rate was held consistent at 47 L/sec and went for seven days.

The water levels were recorded in the pumped well and 4 observation wells, refer Table 3-1 and Figure 1, using data loggers and manual dip tape. Recovery data was also obtained for up to 20 hours after the pumping stopped.

Table 3-1: Well details

Well ID	Standing Water Level (SWL) (m below TOC)	Total Depth (m)	Radial Distance from PB02 (m)	Water level Data
PB2	81.59	168	0	Manual Only
WI08	81.92	168	19	Manual Only
WI06	76.97	90	788	Logger validated to manual
WI03	80.80	199	1004	Logger validated to manual
WI07	75.10	96	1553	Logger validated to manual

3.2 Results

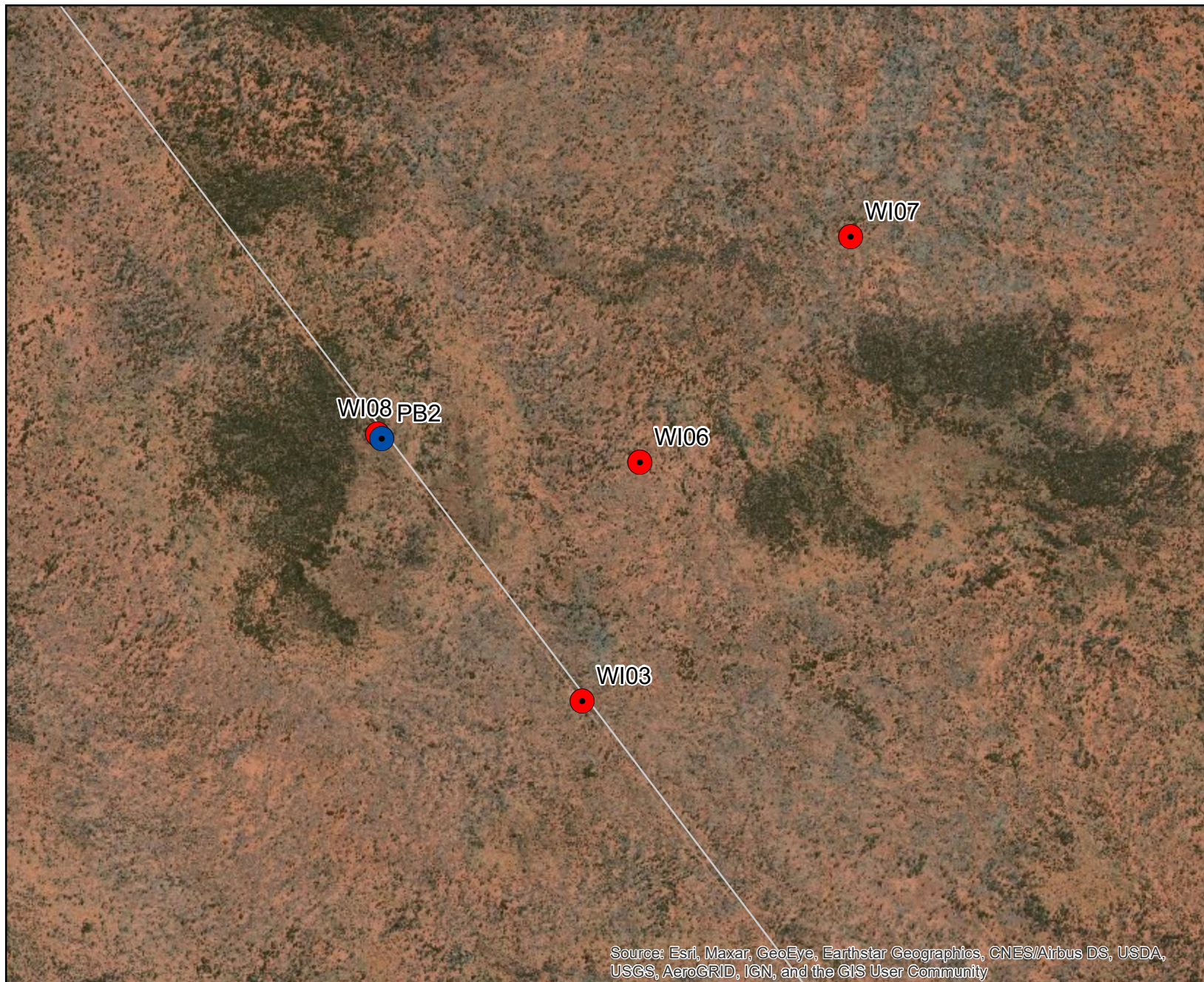
Drawdown was recorded both manually using a dipping tape and using a downhole data logger. Unfortunately for the pumped well PB2 and the observation well WI08, the data loggers failed and only manual measurements are available for analysis. As the drawdown observed from the test were so small, there was generally too of a coarse resolution to analyse (i.e. manually resolution was limited to centimetres whilst the ongoing drawdown was in the range of millimetres). The loggers in other observation wells were successful and this data was used for analysis at WI06, WI03 and WI07 whilst the manual measurements were utilized for PB2 and WI08.

Observed drawdown in the observation wells was minimal, with all wells having less than 7 cm of drawdown after seven days of pumping. The pumped well, PB2, had a total drawdown of 3.18 m. The final drawdowns of each well are shown in Table 3-2.

Table 3-2: Drawdown Observation

Well ID	Maximum Drawdown (m)	Radial Distance from PB02 (m)
PB2	3.18	0
WI08	0.06	19
WI06	0.06	788
WI03*	0.05	1004
WI07	0.05	1553

*Note than WI03 drawdown values were adjusted by - 0.018m after 3am on the 28/08/2020. This was done due to a step change recorded water level which may have happened due to a logger being pulled, checked and re-installed slightly higher in the well.



Legend

- Observation Well
- Pumped Well
- Tracks (250K Topo)
- Stations
- Lease



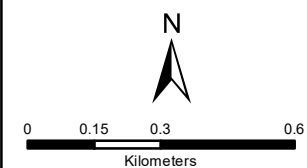
Job Number: VRM-20-1

Client: Verdant Minerals

Version: 1

Date: 30/10/2020

Drawn by: MW



Coordinate System: GDA 1994 MGA Zone 53

Pumping Test Well Locations

Figure 1

The flow rate throughout the constant rate test was maintained at approximately 47 L/sec.

During the constant rate pumping test, the Electrical Conductivity (EC) along with pH was also recorded from PB2, refer Figure 2. EC was relatively consistent at 1600-1650 $\mu\text{S}/\text{cm}$, whilst the pH was stable at around 7.2.

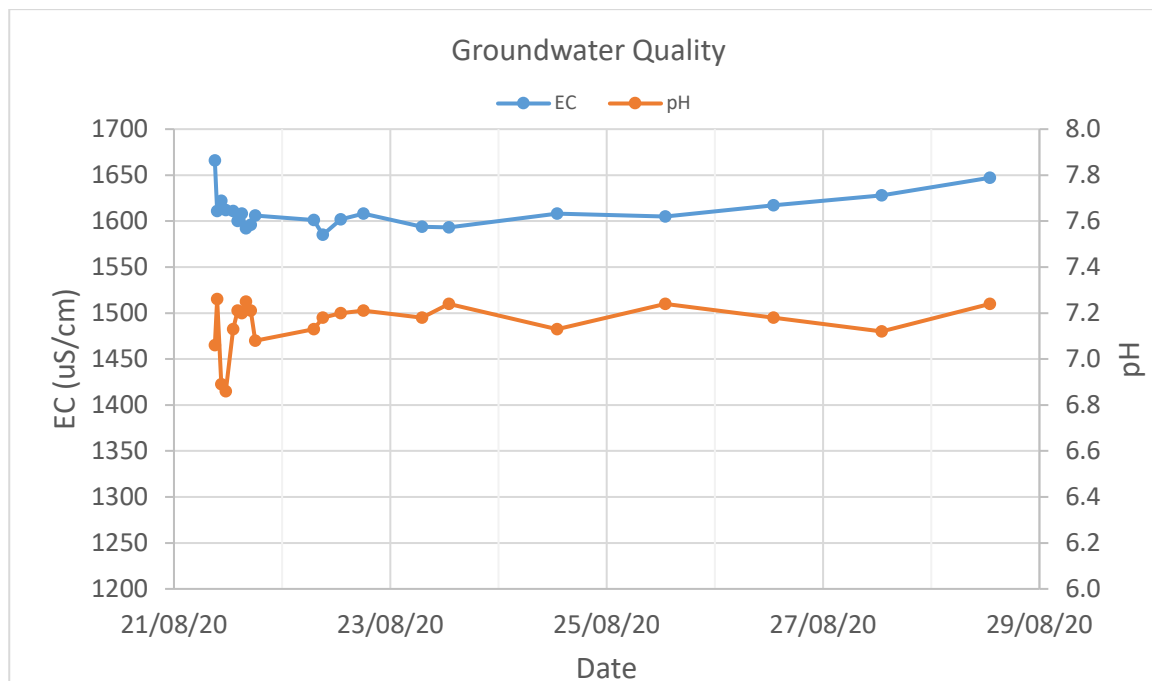


Figure 2: Electrical Conductivity (EC) and pH changes with time at PB2

Laboratory analyses are presented as Appendix B. The laboratory electrical conductivity was stable at approximately 1480 $\mu\text{S}/\text{cm}$.

3.3 Data analysis

Drawdown and recovery data were analysed in excel using the Cooper-Jacob method (1946) outlined in Table 3-3. For wells WI03, WI06 and WI07 the logger data was exclusively analysed (with manual measurements used to verify the data). Manual measurement data was used for PB2 and WI08.

Table 3-3: Aquifer Test data analysis

Method	Use
Cooper-Jacob straight line method ¹	Time-Drawdown during CRT
Cooper-Jacob straight line method ¹	Distance-Drawdown during CRT
Cooper-Jacob straight line method ¹	Residual drawdown after pumping stopped

Time-drawdown graphs for each of the wells can be seen in Appendix A - A1. The late time straight line drawdown trend (dashed black line on Figures) that is indicative of the aquifers Transmissivity was observed after 4 days for WI06, WI03 and WI07 which are all greater than 750 m away from PB2. The same trend in WI08 (only 19 m away) and PB2 was observed in the first few hours.

The estimated Transmissivity and Storativity using the drawdown data is presented in Table 3-4. The very high Transmissivity values (all $>3,500 \text{ m}^2/\text{day}$) are typical of karst limestone aquifers.² The high Storativity is typical of specific yield for an unconfined aquifer.

¹ Cooper, H.H. and C.E. Jacob, 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp. 526-534

² Heath, R.C., 1983. Basic ground-water hydrology, U.S. Geological Survey Water-Supply Paper 2220, 86p

Table 3-4: Time-Drawdown – calculated aquifer parameters

Well ID	Aquifer tested	Transmissivity (m ² /day)	Storativity
PB2	Hagen Member of the Chabalowe Formation	7,431	-
WI08		8,433	0.06
WI06		4,794	0.05
WI03		3,911	0.03
WI07		5,424	0.02

Distance drawdown analysis was also performed using the pumped well and 4 observation wells, see Table 3-5 and Figure 3. It can be seen the calculated transmissivity value is much higher and storativity much lower than the values obtained for the time-drawdown analysis. The discrepancy may be due to slow drainage from the unconfined storage, resulting a delayed drawdown response. Or that the observation wells are completed in a part of the karst system that is only partially connected to the karst features intersected by the production well.

Table 3-5: Distance Drawdown – calculated aquifer parameters

Wells used for analysis	Aquifer tested	Test	Transmissivity (m ² /day)	Storativity
PB02, WI08, WI06, WI03, WI07	Hagen Member of the Chabalowe Formation	PB02 CRT	49,542	0.000312

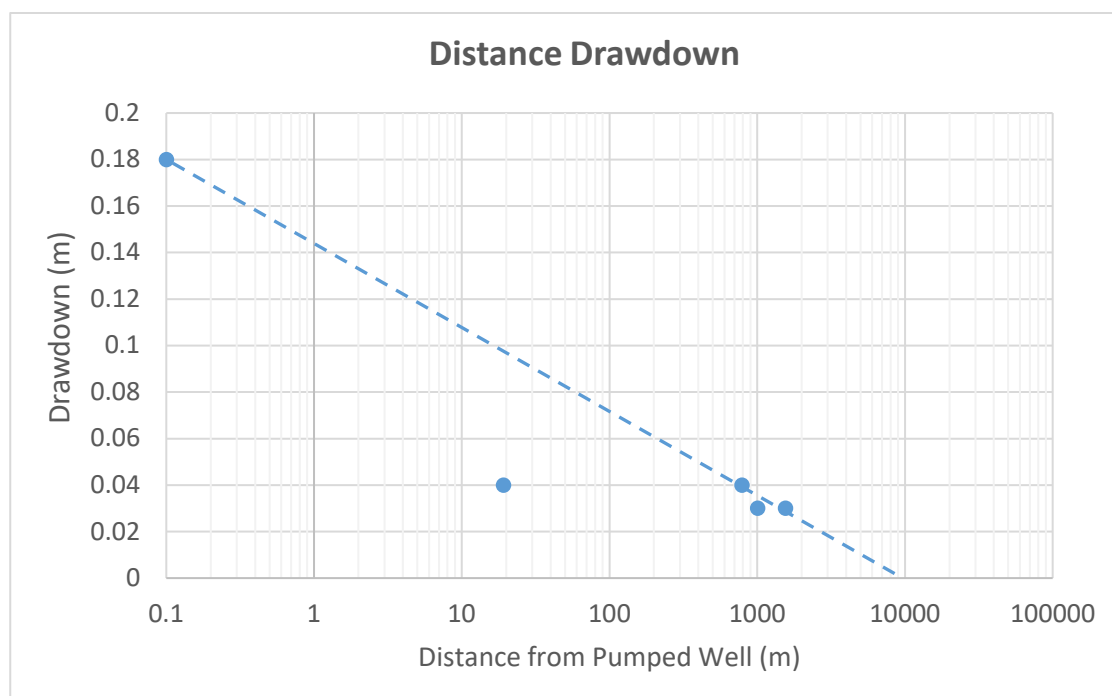


Figure 3: Distance drawdown plot for the pumped well and all observation wells

Aquifer parameters were also calculated using the recovery data from each well, refer Appendix A - A2. The recovery analysis yields a Transmissivity estimate ranging around 20,000 m²/day, see Table 3-6.

Table 3-6: Recovery – calculated aquifer parameters

Well ID	Aquifer tested	Test	Transmissivity (m ² /day)
PB02	Hagen Member of the Chabalowe Formation	PB02 CRT Recovery	17,693
WI08			21,684
WI06			22,519
WI03			18,578
WI07			17,693

Table 3-7: Overview of Aquifer test analysis

Bore Details		Drawdown Analysis				Recovery Analysis		Distance Drawdown Analysis				
ObsBore	radius from pumped bore	drawdown per log cycle	t(o)	T	S	Residual drawdown per log cycle	T	Max Drawdown	Slope Per Log Cycle	Radius of drawdown	T	S
PB02	0.1	0.1	-	7,431		0.042	17,693	3.18	0.04	8,000	37,156	0.01
WI08	19.1	0.1	0.001	7,431	0.05	0.035	21,232	0.04				
WI06	788.3	0.33	2.9	2,252	0.02	0.033	22,519	0.04				
WI03	1003.8	0.19	3.8	3,911	0.03	0.042	17,693	0.03				
WI07	1552.6	0.14	3.3	5,308	0.02	0.040	18,578	0.03				
Average				4,800	0.03		19,000					

The analysis results that appear to best represent the aquifer is those from the time drawdown analysis of observation wells WI06, WI03 and WI07 and the manual data from PB02 and WI08. This is because of a few factors:

- Transmissivity and Storativity results from these wells were all relatively comparable.
- There was logger data for 3 of these wells which provided greater precision and confidence in the analysis.
- The values obtained are reasonable for this type of aquifer.
- The estimates of transmissivity are lower and hence the more conservative values to use for borefield design.

The estimated aquifer parameters are then a Transmissivity of 4,800 m²/day and a Specific Yield of 0.03 (3% v/v)

4 Borefield Design

In order to understand the number and locations of production bores to meet the 10 GL/year (320 L/sec) demand, the principal of superposition was used. In the case of a borefield, the drawdown at a well is the sum of all the individual drawdowns at the well that would have occurred independently (i.e. drawdown at PB2 would be the sum of drawdowns as a result of itself, PB3, PB4, PB5 and PB6 etc.).

As the pumping test indicated that 50 L/sec from a production bore would be sustainable, a borefield consisting of seven wells was designed. 6 bores would almost meet the demand and the extra bore provides contingency for maintenance.

For the borefield analysis, each well was given a flow rate of 50 L/sec (total flow rate of 320 L/sec). With PB02 already a production bore, the additional 6 bores were placed alongside the road with a spacing of 200 m between each bore, refer Figure 4. PB01 is an existing 8-inch bore, with a maximum flow rate of 25 L/s (bore diameter and pump constrained), which will provide additional contingency should it be required.

As the aquifer is understood to end approximately 10 kilometres to the north where the basement is elevated and the Georgina basin sediments thin and are unsaturated, a boundary condition was applied in the analysis. To implement the effect of the boundary, an “image well” was designed 20 km to the north of PB2. The flow rate of this image well was set equal to the total of the borefield (320 L/s).

The transmissivity used in this analysis was the average obtained from the pump test time-drawdown analysis, 4,813 m²/day. This value was chosen to be both conservative whilst also being relatively representative. The storativity used was 0.03, which is the average of the observation wells (from time-drawdown analysis).

The total drawdown at each after 20 years was calculated. The calculated drawdowns at the 7 wells ranged from only 5.8 – 6 m, refer Table 4-1. Each well will have additional drawdown due to well losses (inefficiency of a well), as was observed in PB02, but this is expected to be limited to a few metres comparable to PB02.

Table 4-1: Proposed Borefield

Well ID	Easting	Northing	Calculated Drawdown after 20 years (m)	Well status
PB03	503335	7618280	6.7	Complete
PB04	503452	7618119	6.9	Proposed
PB02	503569	7617958	7.1	Proposed
PB05	503686	7617797	7.1	Proposed
PB06	503805	7617635	7.0	Proposed
PB07	503924	7617473	6.9	Proposed
PB08	504051	7617316	6.6	
PB01*	504178	7617160	-	Complete

*) PB01 will remain in the proposed borefield, allowing for a redundancy. It was not modelled as being on in this scenario, with the full 241 L/sec being allocated to PB2 – PB6.

The minimal drawdown estimated at each location shows that 7 production bores will be adequate for the 10 GL/year pumping rate. Maximum drawdown is approximately 7 m after 20 years pumping. Available drawdown is around 40m, which indicates that the borefield will have additional capacity to pump for much longer than 20 years.

The additional 6 bores should be constructed the same as PB02:

- 323mm steel casing to ~120 m
- Open hole production interval to total depth of ~170 m

5 Cost Estimate

5.1 Capital Cost Estimate

The Capital cost estimate for the borefield is provided in Table 5.1. The total cost is \$2.5 M there is no contingency applied in this estimate. Costs are reasonably well constrained since they are based on replication of drilling PB02, and a fixed price vendor quote for the pump supply and install.

Bores specified as identical to the test bore PB02.

The submersible pump is designed to yield 50 L/s with 300KPA at the bore head. The Vendor quotation is included as Attachment 1.

Engineering and project management is relatively low at 10% however the project is straight forward and the largest cost item is the installation of pumps, which will require limited engineering input.

Table 5.1: Capital Cost Estimate.

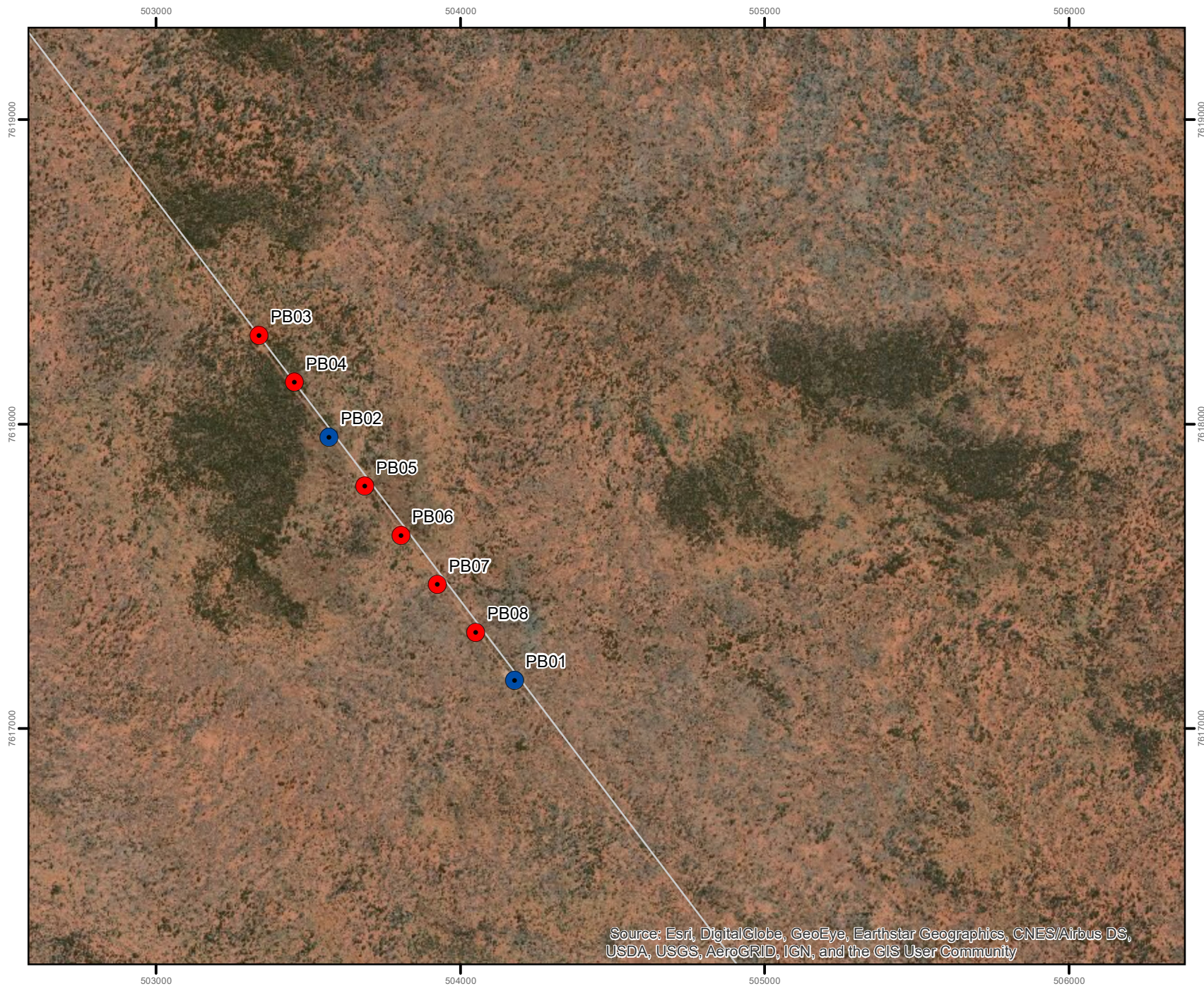
Item	Quantity	Cost	Total	Basis	Vendor	Description
Drilling Pilot Bore / Observation Bore	6	\$30,000	\$180,000	Vendor Pricing	Tomlin Drilling	6 inch bore, PVC Casing
Drilling Production Bores	6	\$90,000	\$540,000	Cost of PB02	Tomlin Drilling	323mm casing to 120m 250mm open hole to 170m depth
Submersible Pumps	7	\$ 226,767	\$1,587,367	Vendor Pricing	Thinkwater Alice Springs	Supply and Install CAPRARI 60HZ 460V 92KW SS SUB PUMP AND CABLING, VSD pump control, Electrical from Pump to control box. Concrete slab and enclosure
Engineering and Project Management	1	\$ 461,473	\$230,737	20% of project Total	Groundwater Science	Planning, permitting, contractor engagement, contractor management
Total			\$2,538,103			

5.2 Operating Costs

Operating costs will be power consumption at 87kw per pump during duty for a total of 522 Kw.

Maintenance for submersible pumps is low. Complete pump replacement every 10 years is a reasonable cost assumption.

Daily borefield inspection is likely to be needed to ensure the borefield is operating as designed.



Legend

Exists

- Planned
- Existing

— Tracks (250K Topo)



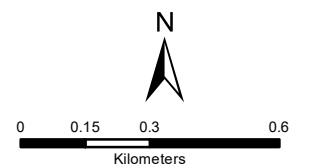
Job Number: VRM-20-1

Client: Verdant Minerals

Version: 1

Date: 12/11/2020

Drawn by: MW



Coordinate System: GDA 1994 MGA Zone 53

Proposed Bore Locations

Figure 4

6 Conclusions and recommendations

The seven-day pump test undertaken at the Amaroo Phosphate Project confirmed the very high transmissivity within the target aquifer at the site of approximately 4,800 m³/day/m. The specific yield estimate is 0.03.

The drawdown at the observation wells were minimal, ranging from 0.05 – 0.06 m after 7 days pumping at 47 L/s. The high transmissivity values are typical of karst limestone aquifers, allowing for substantial flow rates in production bores.

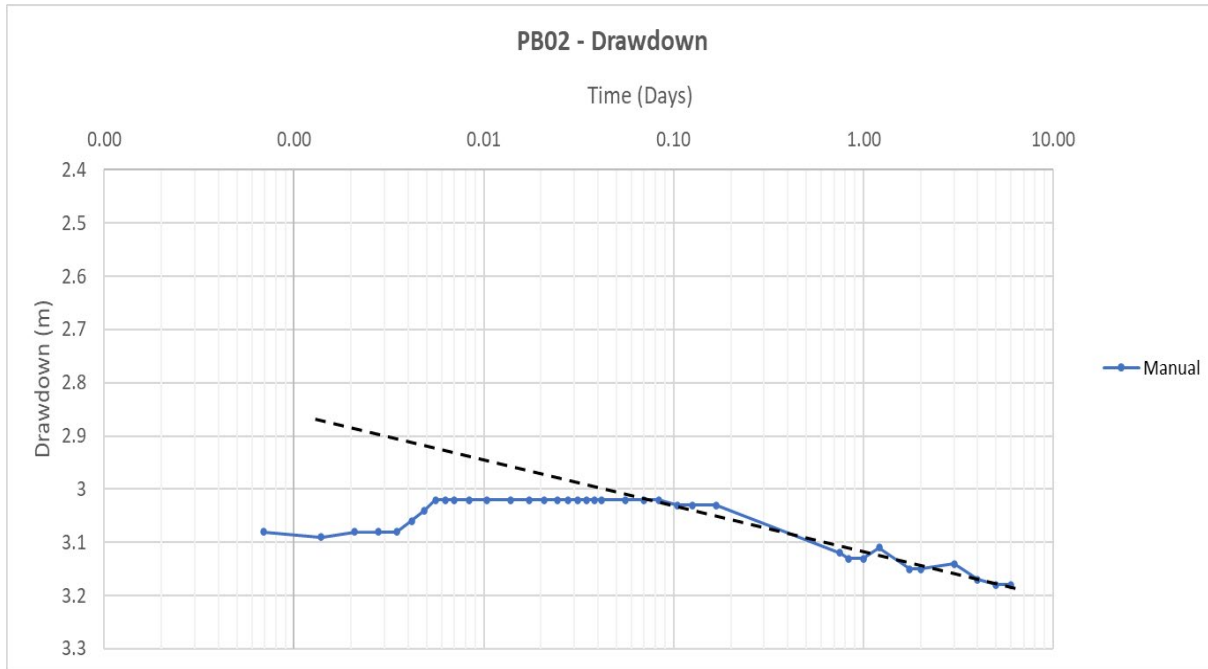
The proposed borefield is comprised of 7 wells located 200 m from each other along the road (6 pumping wells and one contingency). Keeping the bores as close to each other as possible will reduce the infrastructure required (i.e. electrical cabling and pipework). One of these wells already exists (PB2) so there are only 6 production bores that need to be constructed. The 4 bores should be constructed in the same manner as PB2. PB01 is an existing 8-inch bore capable of producing 25 L/sec. which will provide a contingency should it be required. The 7 production bores are designed to yield 50 L/sec each (or 11 GL/year total) with minimal drawdown impacts on the aquifer.

7 REFERENCES

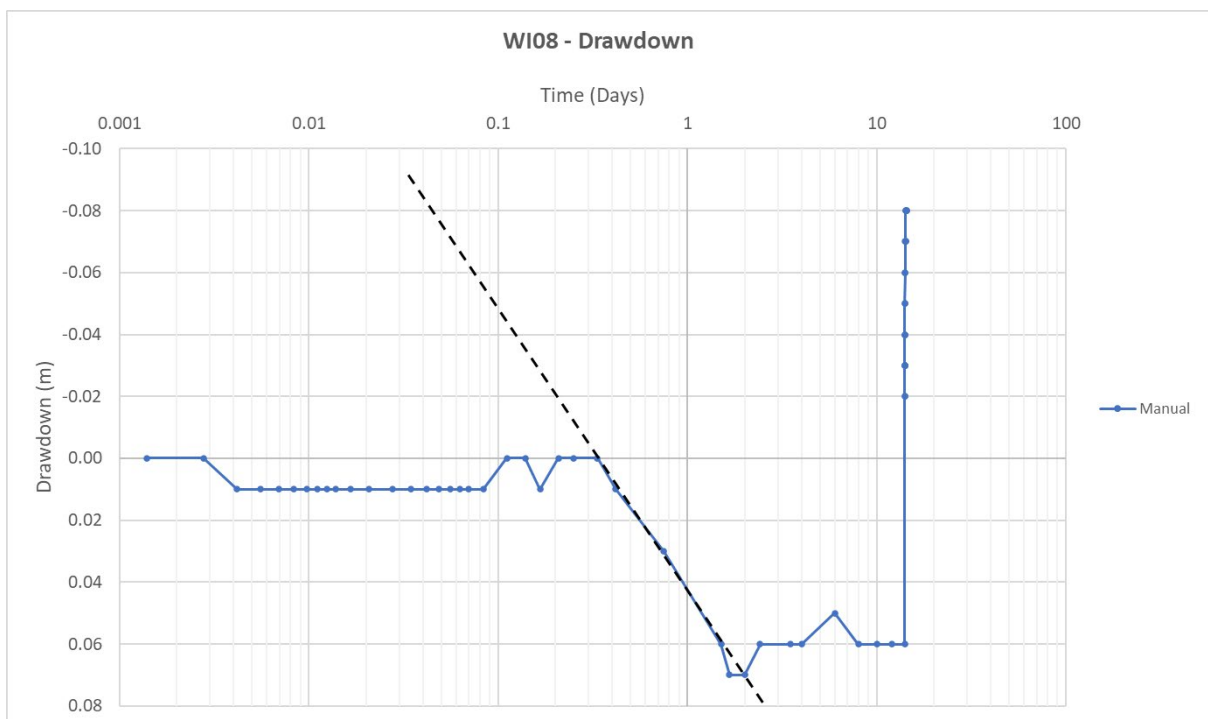
- ¹ Cooper, H.H. and C.E. Jacob, 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp. 526-534
- ² Heath, R.C., 1983. Basic ground-water hydrology, U.S. Geological Survey Water-Supply Paper 2220, pp.86
- 3 Driscoll, F.G., 1986. Groundwater and Wells, 2nd Edition, Johnson Division, St Paul, 1089, pp. 259
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- GWS Jan 2014 *Ammaroo Phosphate Project Water Supply Production Bore – Pump Installation and Testing Report*. Groundwater Science Pty Ltd, Adelaide. Consultant's Report to Rum Jungle Resources.
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Appendix A

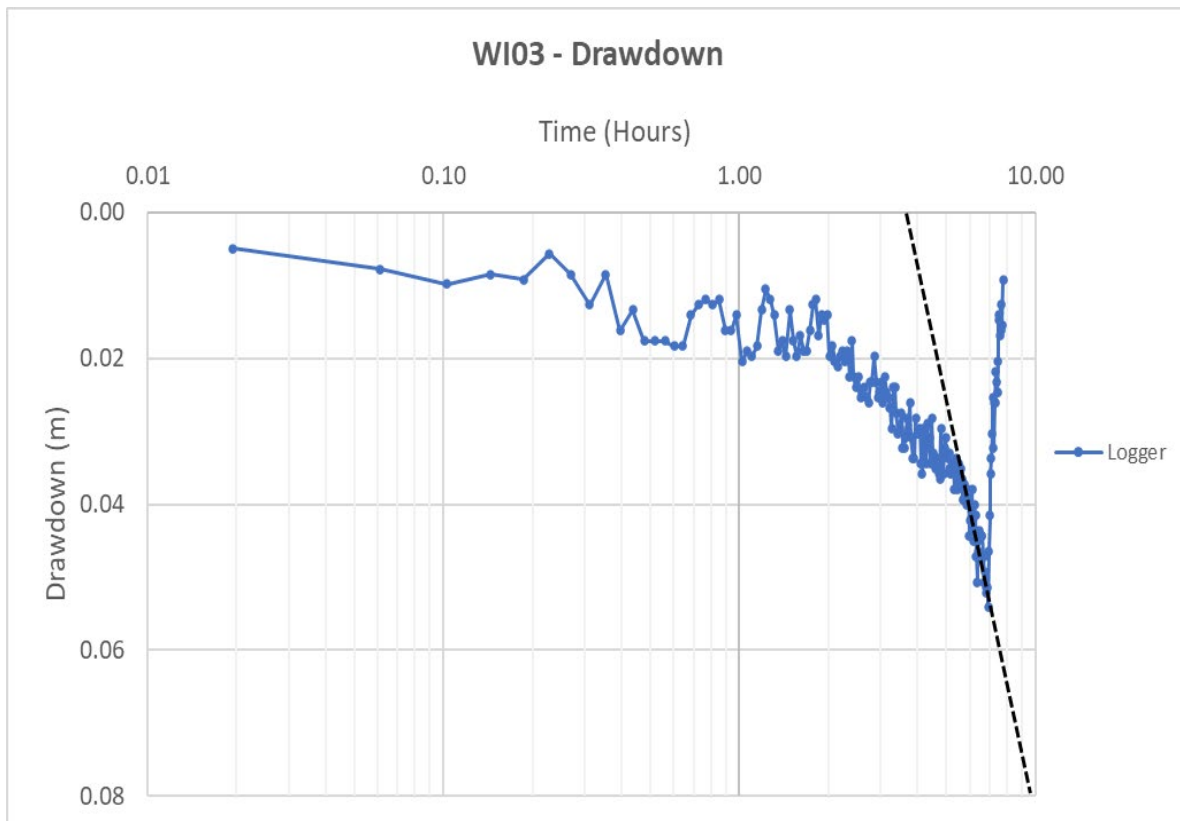
A1. Time Drawdown Graphs



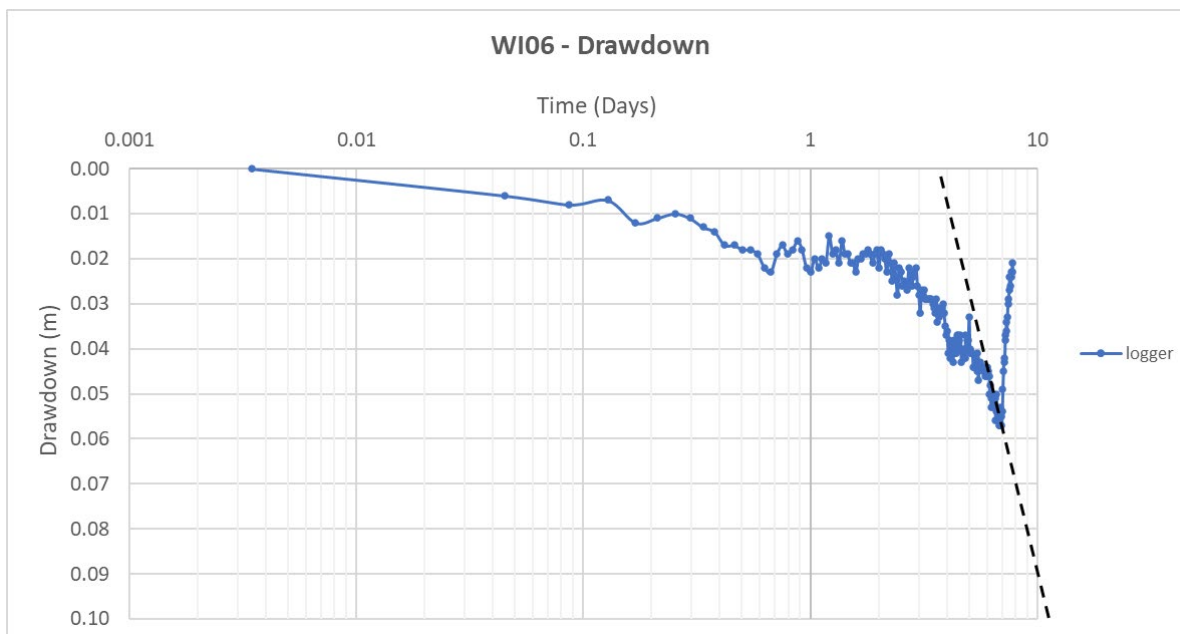
Time drawdown data and analysis for PB02



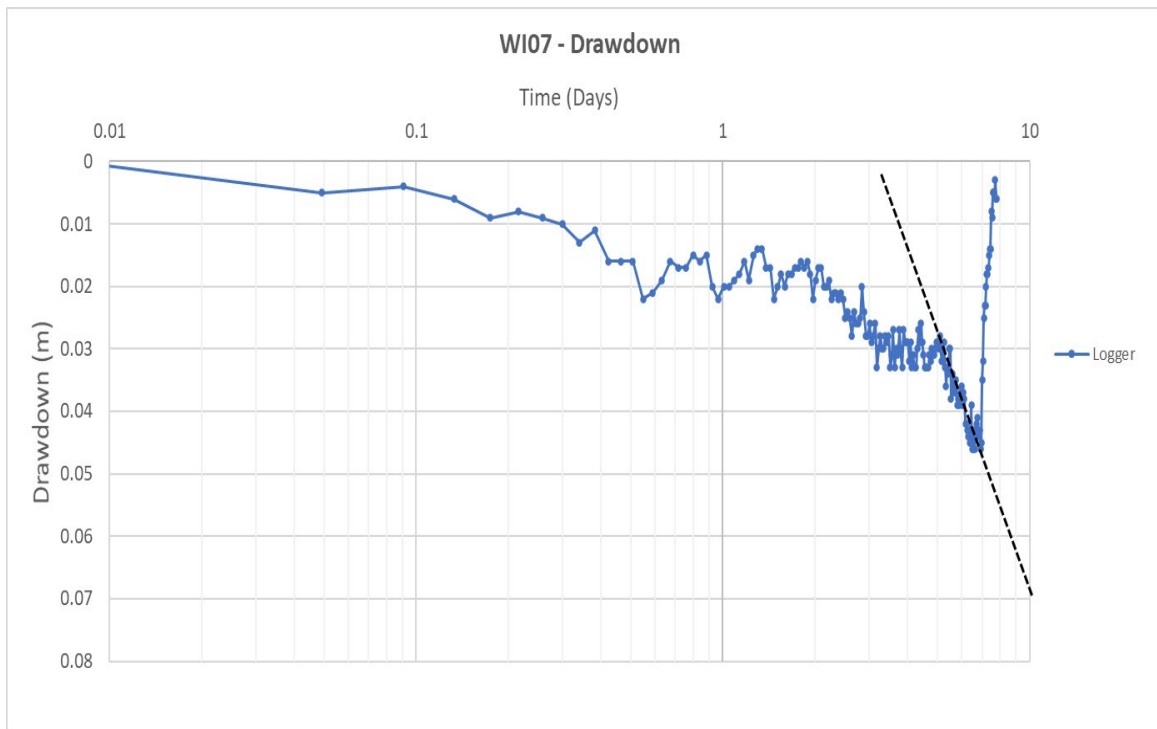
Time drawdown data and analysis for observation well WI08



Time drawdown data and analysis for observation well WI03

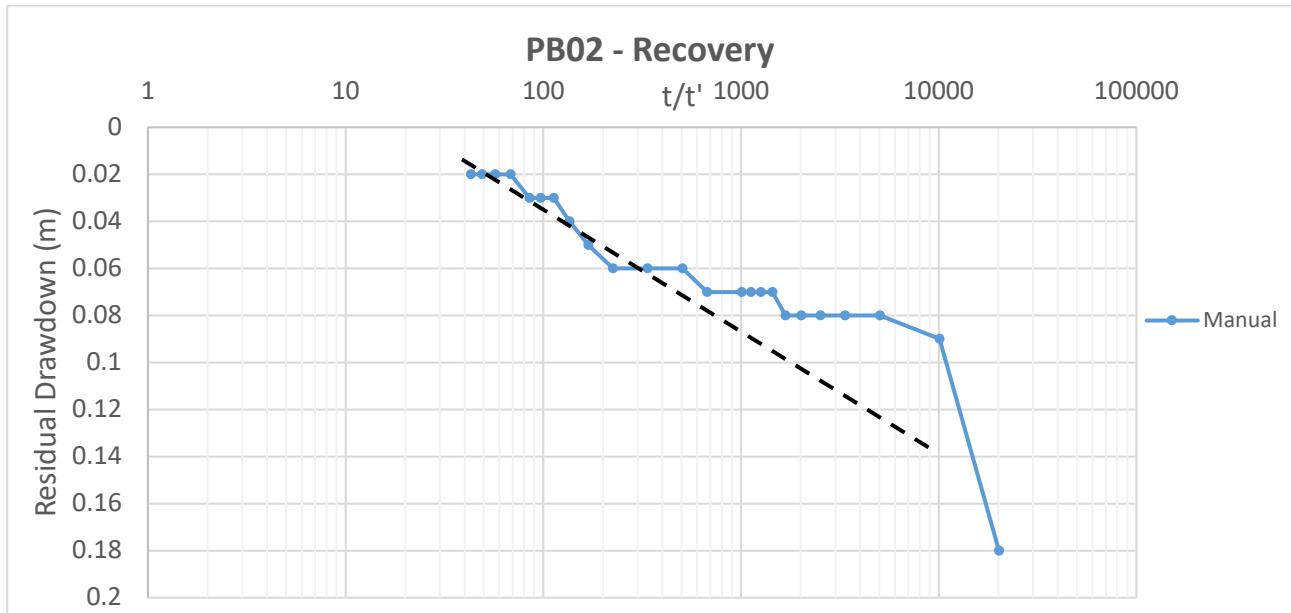


Time drawdown data and analysis for observation well WI06

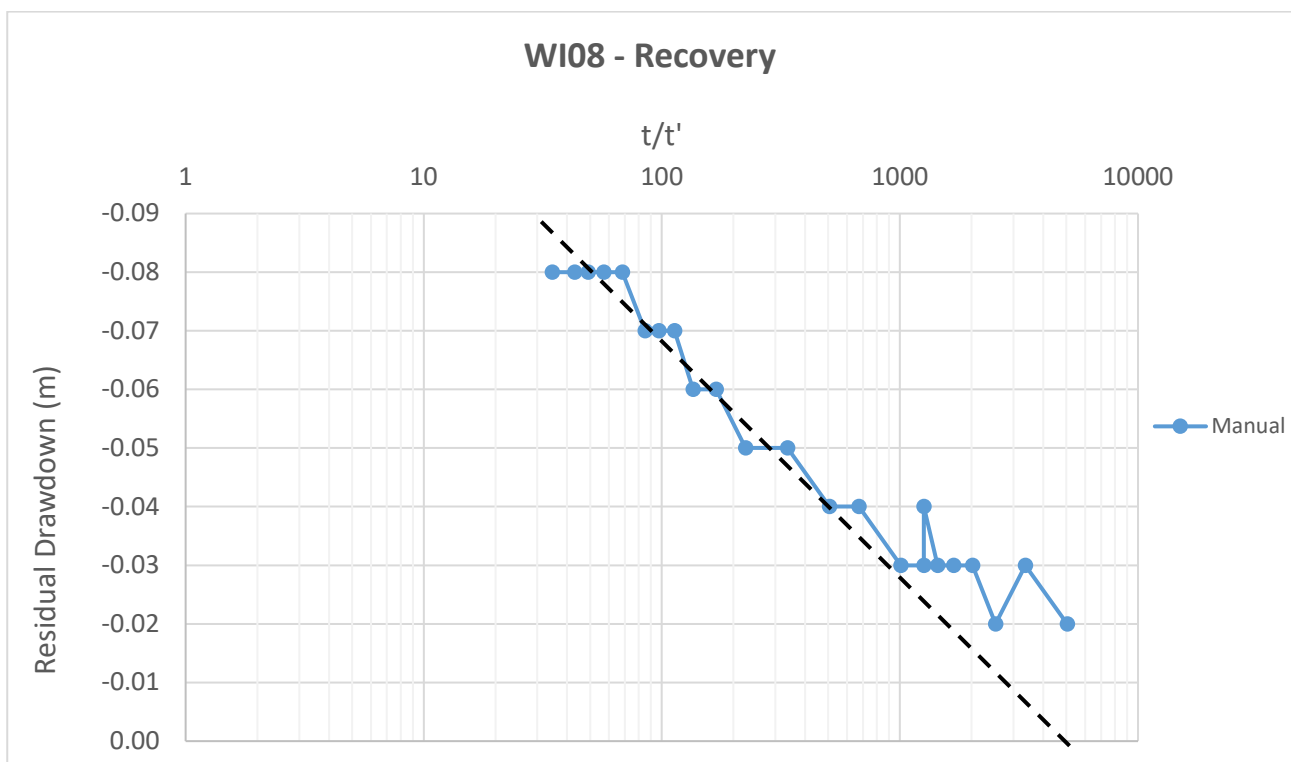


Time drawdown data and analysis for observation well WI07

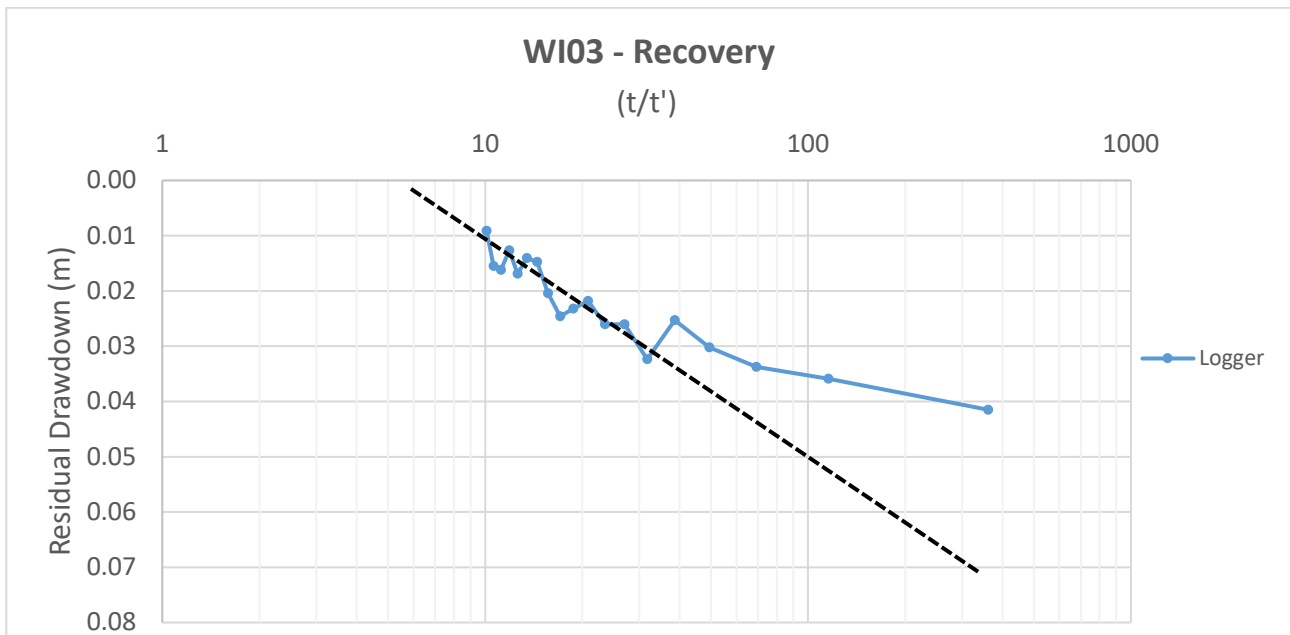
A2. Recovery Graphs



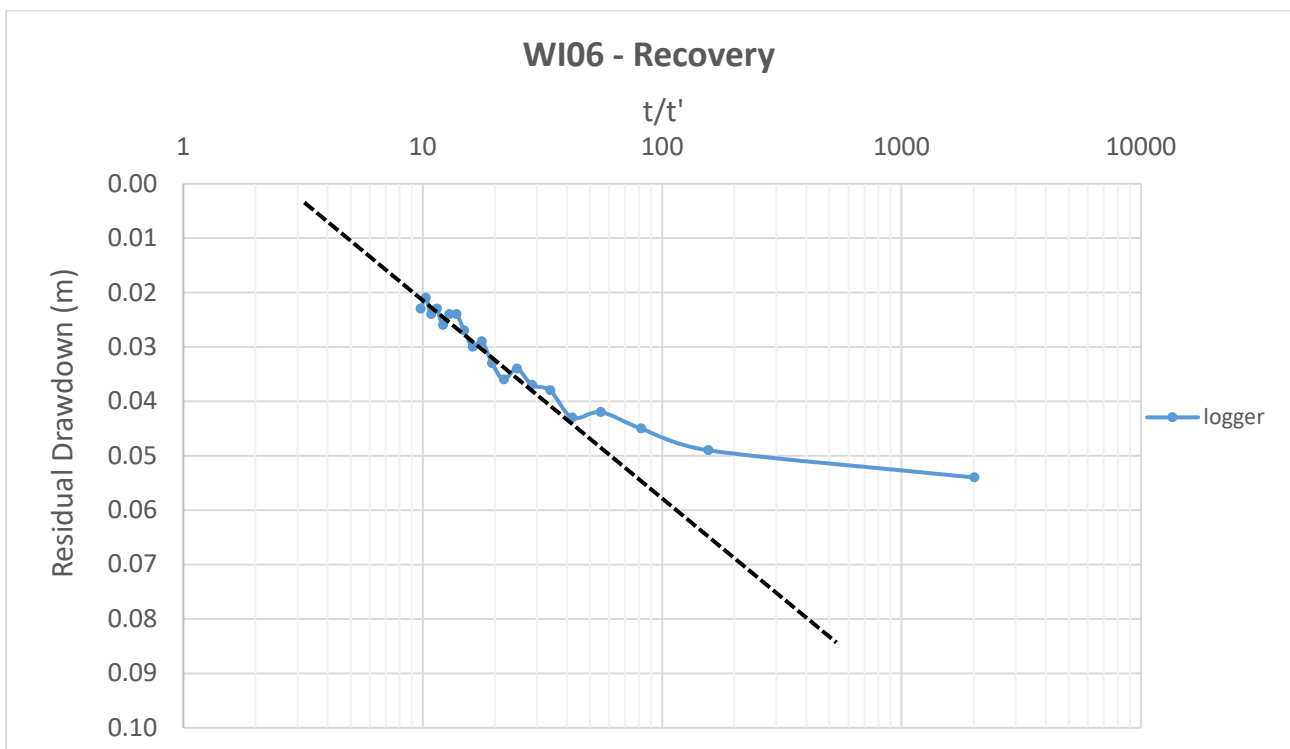
Recovery data and analysis for pumped well PB02



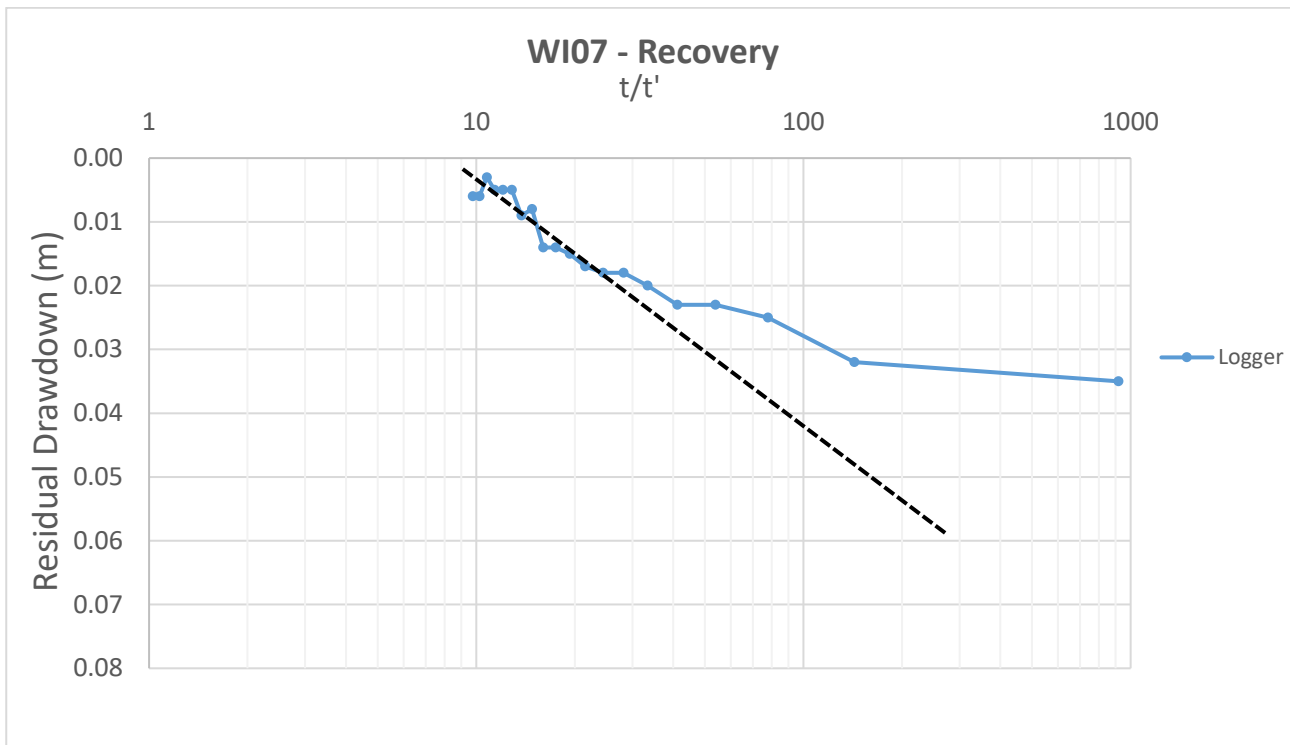
Recovery data and analysis for observation well WI08



Recovery data and analysis for observation well WI03



Recovery data and analysis for observation well WI06



Recovery data and analysis for observation well WI07

Appendix B Groundwater Quality

Production Bore PB02 Samples Taken Daily from 21/8/

IDENT	UNITS	21/8	22/8	23/8	24/8	25/8	26/8	28/8
EC	µS/cm	1500	1500	1470	1510	1450	1450	1510
TSS	mg/L	<10	<10	<10	<10	<10	<10	<10
F	mg/L	0.9	0.9	0.9	0.9	0.9	0.9	0.9
NH3_N	mg/L	0.01	0.015	0.01	0.01	0.01	0.015	0.015
Total N	mg/L	7.57	7.33	7.3	7.43	7.44	7.44	8.08
Total P	mg/L	0.01	0.01	0.01	0.01	0.005	0.005	0.005
As_F	µg/L	0.65	0.55	0.65	0.6	0.55	0.55	0.65
As_T	µg/L	0.75	0.75	0.65	0.65	0.6	0.65	0.75
Ba_F	µg/L	39	39.6	40.2	38.2	39.8	38.8	40.2
Ba_T	µg/L	42	40.2	41	40.4	41.2	41.6	40.8
Be_F	µg/L	<0.05	0.05	<0.05	<0.05	<0.05	0.05	<0.05
Be_T	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cd_F	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cd_T	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Co_F	µg/L	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
Co_T	µg/L	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
Cr_F	µg/L	0.9	0.8	0.8	0.7	0.8	0.7	0.8
Cr_T	µg/L	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Cu_F	µg/L	2.6	2.65	2.8	3.04	2.06	2.18	2.67
Cu_T	µg/L	2.64	2.74	3.33	3.67	2.04	2.33	2.69
Hg_F	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Hg_T	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mn_F	µg/L	0.7	0.62	0.73	0.47	0.55	0.51	0.68
Mn_T	µg/L	0.87	0.73	1.72	0.61	0.67	0.52	0.76
Ni_F	µg/L	0.74	2.94	51.3	18.7	2.62	2.31	11.6
Ni_T	µg/L	0.8	3.02	51.5	20.2	3.02	2.93	13.1
Pb_F	µg/L	1.85	2.13	3.68	2.04	1.21	1.02	1.48
Pb_T	µg/L	2.3	2.46	4.3	2.37	1.38	1.18	1.49
V_F	µg/L	3.9	3.85	3.9	3.8	4.35	3.9	4
V_T	µg/L	3.9	4.1	4.05	4.1	4.35	4.15	4.1
Zn_F	µg/L	30.5	62.6	119	83.3	93.1	77.7	97
Zn_T	µg/L	31.5	65.2	120	88.9	94.4	83.6	98.3

Appendix C Vendor Quotes

C1. Bore Construction (Tomlin Drilling)

Summary:

Mobilisation = \$6,720

Drill 6 x 6" cased bores to 100 - 150m = \$109,980

1 x 12" Steel Cased production Bore 120 - 200m = \$77,800

3 x 8" Pilot Holes to 200m = \$112,632

Pump Test

Mobilisation = \$2,880

Total for 72 Hour Constant Rate Test = \$48,240

Total for 168 Hour Constant Rate Test = \$90,480

Mobilisation

Drilling Equipment Mobilisation	320	\$21.00	\$6,720
Pump Test Mobilisation	320	\$9.00	\$2,880

Drill 6 x 6" cased bores to 100 - 150m**Total = \$109,980**

Description	Quantity	Unit Price	Amount
Drill to suit 219mm Steel Casing	6	\$140	\$840
Supply, cement and install 219mm Steel Casing	6	\$110	\$660
Drill to suit 168mm Steel Casing	54	\$120	\$6,480
Supply, slot and install 168mm Steel Casing	60	\$80	\$4,800
Airlift	3	\$650	\$1,950
Headworks	1	\$1,000	\$1,000
Worktime	4	\$650	\$2,600
			\$18,330

Accounts

1 x 12" Steel Cased production Bore 120 - 200m

Total = \$77,800

Description	Quantity	Unit Price	Amount
Drill to suit 404mm Steel Casing	6	\$345	\$2,070
Supply, cement and install 404mm Steel Casing	6	\$230	\$1,380
Drill to suit 323mm Steel Casing	114	\$275	\$31,350
Drill 250mm hole 120m to 200m	80	\$165	\$13,200
Supply and install 323mm Steel Casing	120	\$175	\$21,000
Airlift	4	\$650	\$2,600
Headworks	1	\$1,000	\$1,000
Worktime	8	\$650	\$5,200
			\$77,800

3 x 8" Pilot Holes to 200m

Total = \$112,632

Description	Quantity	Unit Price	Amount
Drill to suit 219mm Steel Casing	6	\$140	\$840
Supply, cement and install 219mm Steel Casing	6	\$110	\$660
Drill to suit 168mm Steel Casing	200	\$120	\$24,000
Supply and install 50mm Class 18 PVC Casing	192	\$9.00	\$1,728
Supply and install 50mm Class 18 PVC Casing, Slotted	12	\$18	\$216
Airlift	6	\$650	\$3,900
Headworks	1	\$1,000	\$1,000
Worktime	8	\$650	\$5,200
			\$37,544

ABN: 50167637676



66 Smith St Alice
Springs NT 0870
Ph: 0417 885 410
Fax: 08 8952 7017

Pump Test up to 50l/s 3 to 7 days

Total for 72 Hour Constant Rate Test = **\$48,240**

Total for 168 Hour Constant Rate Test = **\$90,480**

Install/Pull pump, Set up headworks and monitor bores	1	\$6,000	\$6,000
4 x 100 min step test	6	\$440	\$2,640
72 hour Constant Rate Test	72	\$440	\$31,680
Monitoring Recovery, (day time or manned)	24	\$330	\$7,920
			\$48,240

Notes:

Worktime includes installing V notch weir. Shifting.
Tripping for running casing, changing drill size,
airlift.

C2. Pump Supply and Install (Thinkwater Alice Springs)



Chambers Trade Services Pty Ltd
 PO Box 4425
 ALICE SPRINGS NT 0871
 PH 08 8952 1844
 FAX 08 8953 0748
 Email alicesprings@thinkwater.com.au

ABN. 28 601 228 871

Order Date 20.01.2021
Reference VERDENT PHOSPH
Your Ref
Sales Person PETER

TO ACCOUNT

TRADE (CASH ONLY)
 NT

DELIVERY:

VERDENT PHOSPHATE
 AMMAROO PROJECT
 BORE FIELD

Code	Description	Qty	List Price	Disc.	GST	Total(ex GST)	Total (Inc GST)
PROJECT	SUPPLY AND INSTALL 6 BORE PUMPS	1.00	1,236,908.00		123,690.80	\$1,236,908.00	\$1,360,598.80

SUPPLY AND INSTALL 6 X SUMERSIBLE PUMPING SYSTEMS 50 LITRES PER SEC AT 140M TDH.

6 X CAPRARI 60HZ 460V 92KW SS SUB PUMP AND CABLING.
 6 X 110 KW VSD DRIVES.
 6 X 150MM CRUSADER HOSE FLEXI BORE RISING MAINS.
 6 X 150MM HEAD WORKS TO CUSTOMER CONNECTION POINT 150MM FLANGE PLATE.
 6 X ELECTRICAL BETWEEN BORE HEAD AND VSD.

6 X Clear and grub site.
 6 X Form, pour and finish new concrete bore head slab.
 6 X Form, pour and finish new switchboard concrete slab.
 6 X install new bore cap.
 6 X Install new switchboard shelter.
 6 X Install down hole gear.
 6 X Install pipework and valves.
 6 X Install electrical conduits as required.
 6 X Install new 1800 chainmesh compound fencing complete with double gates.
 6 X Install 20/14 aggregate to compound.

1 X TRAVEL TO SITE

THINKWATER TO SUPPLY ON SITE ACCOMMODATION ON SITE

PRICING IS FOR 6 SITES TO BE DONE ON 1 TRIP IF MULTIPLE TRIPS REQUIRED EXTRA TRAVEL AND ACCOMMDATION WILL BE REQUIRED.

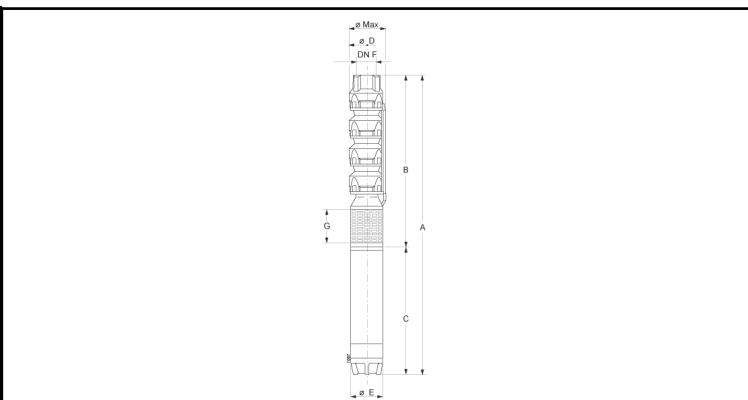
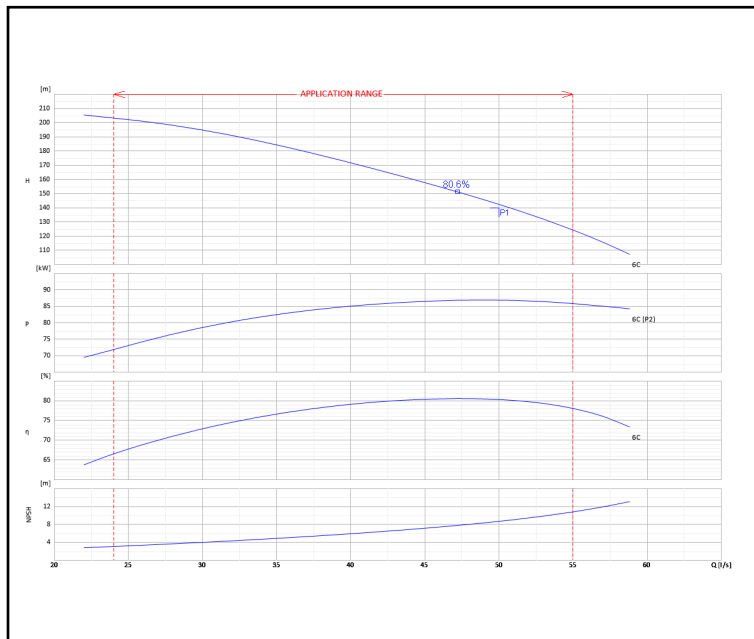
SubTotal \$1,236,908.00
G.S.T. \$123,690.80
Total \$1,360,598.80

ALL PRICES ARE QUOTED AS A PACKAGE, AND UNLESS NEGOTIATED PRIOR ARE UNABLE TO BE ORDERED SEPERATELY

Customer	U/X / BMD F TQSJOHT		
Offer		Date	17/12/2020

Item	Description	Quantity
1	SUBMERSIBLE ELECTRIC PUMPS	
1.0	E8P135U/6C+MAC8125-8Z 60HZ 380;460V ELECTRIC SUBMERSIBLE PUMP	1
Item	Description	Quantity
2	STAINLESS STEEL BOREHOLE ELECTRIC PUMPS	
2.0	E8PX135/6C+MACW8125-8Z 60HZ 380;460V ELECTRIC SUBMERSIBLE PUMP	1

Customer:		Ref.:	
Item	1	Quantity	1
Type	SUBMERSIBLE ELECTRIC PUMP		Model
			E8P135U/6C+MAC8125-8Z



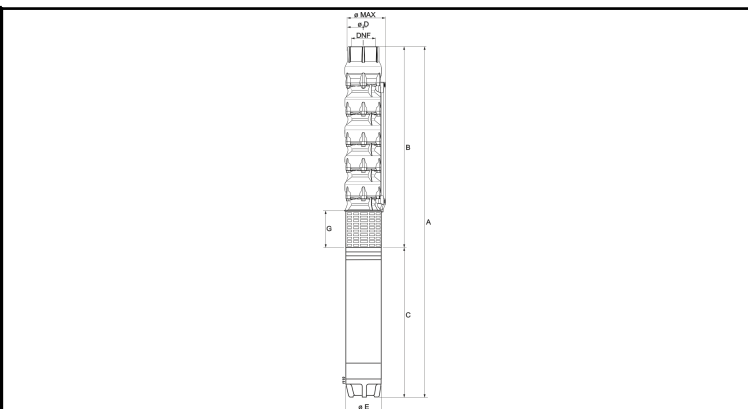
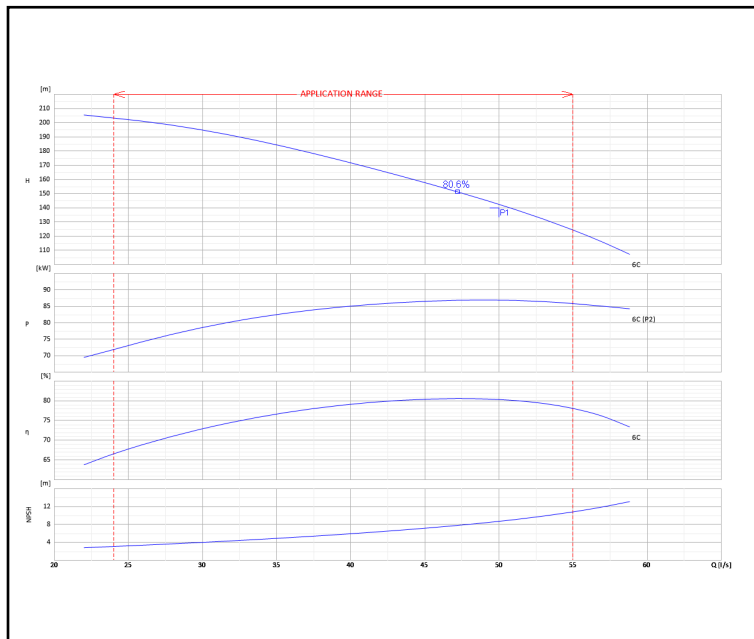
Dimensions [mm]							
A	2975.5						
B	1290.5						
C	1685						
D	192						
E	191						
F	G5						
G	193.5						
Ø max	203						

DATI FUNZIONAMENTO					- ISO 9906:2012 3B -			CONSTRUCTION CHARACTERISTICS		
Q [l/s]	H [m]	P [kW]	[%]	NPSH [m]	Delivery diameter	G5	-			
50	142.4	86.9	80.3	8.7	Max. overall diameter	203	mm			
					Electric pump weight	359	Kg			
					No. Stages	6				
					Tenuta motore	-				
					Type of installation	Vertical				

OPERATING LIMITS					PUMP MATERIALS					
Pumped liquid		Water								
Temperatura max. pumped liquid		30			Diffuser unit		Cast iron			
Maximum density		1	kg/dm³		Suction support		Cast iron			
Maximum viscosity		1	mm²/s		Impeller		Cast iron			
Max. solid content		-			Shaft		Stainless steel			
Max. no. starts/hr		6			Coupling		Stainless steel			
Minimum immersion depth		507.5	mm		Pump shaft bearing bush		Stainless steel/rubber			
OPERATING CHARACTERISTICS					Valve casing		Cast iron			
					Conical valve		Stainless steel			
Service flow rate		50.27	l/s		Strainer		Stainless steel			
Service head		141.51	m		Ring impeller		Steel/Rubber			
Qmin	Qmax	24	55	l/s						
H (Q=0)	Hmax (Qmin)	231.42	203.31	m						
Power consumption at duty point		86.9	kW							
Pump efficiency	overall eff.	80.25	70.1	%						
Max. pump efficiency (B.E.P.)		80.6		%						
Sense of rotation (*)		Anticlockwise								
Number of pumps installed		Operating		Stand-by		MOTOR MATERIALS				
		1		0						
ELECTRIC MOTOR CHARACTERISTICS										
Nominal power		92		kW		Shaft		Stainless steel		
Rated frequency		60		Hz		Upper bracket		Cast iron		
Rated voltage		460		V		Rotor		Electrical steel		
Rated current		155.6		A		Stator		Electrical steel		
No. Poles	Rotation speed	2	3515	1/min		Stator shell		Stainless steel		
Insulation class		-			Winding		Green wire			
Certified motor for use with drinking water					Lower bracket		Cast iron			
					Mechanical seal		Silicon carbide/silicon carbide			
					Bearing bush		Bronze			
					Thrust-bearing		Stainless steel/Synthetic compound			

Note:	
OFFER No. :	Pos. 1.1
	Date 17/12/2020

Customer:		Ref.:	
Item	2	Quantity	1
Type	SUBMERSIBLE ELECTRIC PUMP		Model
		Required flow rate	50 l/s
		Required head	140 m
			E8PX135/6C+MACW8125-8Z



Dimensions [mm]							
A	2975.5						
B	1290.5						
C	1685						
D	192						
E	191						
F	G5						
G	193.5						
Ø max	203						

DATI FUNZIONAMENTO					- ISO 9906:2012 3B -			CONSTRUCTION CHARACTERISTICS		
Q [l/s]	H [m]	P [kW]	[%]	NPSH [m]	Delivery diameter	G5	-			
					Max. overall diameter	203	mm			
					Electric pump weight	328.5	Kg			
					No. Stages	6				
					Tenuta motore	-				
					Type of installation	Vertical				

OPERATING LIMITS					PUMP MATERIALS			
Pumped liquid		Water			Diffuser unit		Stainless steel	
Temperatura max. pumped liquid		30			Suction support		Stainless steel	
Maximum density		1	kg/dm³		Impeller		Stainless steel	
Maximum viscosity		1	mm²/s		Shaft		Stainless steel	
Max. solid content		-			Coupling		Stainless steel	
Max. no. starts/hr		6			Pump shaft bearing bush		Stainless steel/rubber	
Minimum immersion depth		507.5	mm		Valve casing		Stainless steel	
OPERATING CHARACTERISTICS					Strainer		Stainless steel	
Service flow rate		50.27	l/s		Ring impeller		Stainless steel/rubber	
Service head		141.51	m					
Qmin	Qmax	24	55	l/s				
H (Q=0)	Hmax (Qmin)	231.42	203.31	m				
Power consumption at duty point		86.9	kW					
Pump efficiency	overall eff.	80.25	70.1	%				
Max. pump efficiency (B.E.P.)		80.6		%				
Sense of rotation (*)		Anticlockwise						
Number of pumps installed		Operating		Stand-by	MOTOR MATERIALS			
		1		0				
ELECTRIC MOTOR CHARACTERISTICS					Shaft		Stainless steel	
Nominal power		92		kW	Upper bracket		Stainless steel	
Rated frequency		60		Hz	Rotor		Electrical steel	
Rated voltage		460		V	Stator		Electrical steel	
Rated current		155.6		A	Stator shell		Stainless steel	
No. Poles	Rotation speed	2	3515	1/min	Winding		Green wire	
Insulation class		-			Lower bracket		Stainless steel	
Certified motor for use with drinking water					Mechanical seal		Brass/Synthetic compound	
					Bearing bush		Bronze	
					Thrust-bearing		Stainless steel/Synthetic compound	

Note:	
OFFER No. :	Pos. 2.1
	Date 17/12/2020